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ABSTRACT

This manual is designed by the Massachusetts Cooperative Extension Service as a guide for the control of the most common insects and related pests of floricultural crops grown commercially in glass and plastic houses in Massachusetts. The publication consists of two sections. The first section presents a description of the major pests of floricultural crops, their biology, and the damage they cause. Some of these pests include aphids, beet armyworm, cockroaches, cutworms, leaf miners, loopers, mites, scale insects, slugs and snails, thrips and whiteflies. This is followed by general information and the methodology for using pesticides effectively and safely. The second section provides information on the control of pests on specific crops such as pesticide formulations and methods of application, safety precautions, storage of pesticides, pesticide delivery calculations, the safe use of temik, toxicity of pesticides and reported phytotoxicity of Acaricides and insecticides to ornamentals. The metric system and poison centers in Massachusetts are also presented at the end of the manual. (HM)

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Floricultural Insects and Related Pests — Biology and Control

SECTION I

A.G. Gentile
&
D.T. Scanlon

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BIOLOGY AND CONTROL OF INSECTS AND RELATED PESTS OF FLORICULTURAL CROPS IN MASSACHUSETTS

FOR COMMERCIAL GROWERS ONLY

A. G. GENTILE AND D. T. SCANLON*

PREFACE

This manual has been prepared as a guide for the control of the most common insects and related pests of floricultural crops grown commercially in glass and plastic houses in Massachusetts.

Because the behavior of pests and growing conditions may vary with locations and specific crops, the information provided cannot be considered as applicable in all situations. Moreover, State and Federal regulations may suspend or modify the use of some of the suggested chemicals and pest control methods and new chemicals may receive registration. Additional information for specific situations should be secured from certified Extension Entomologists, Extension Specialists, the State Chemical Leader or the State Regulatory Agency.

Under forthcoming new State and Federal regulations, a number of highly toxic pesticides will be classified as "restricted", for use only by certified applicators. Rules and regulations for safeguarding workers, consumers and the environment will be more strictly enforced. Since registration of pesticides for local use varies from state to state, the grower should always adhere to local use registrations and secure information from official regulatory personnel.

In view of these developments, it is highly desirable that everyone concerned with insect pest control on commercial floricultural crops in Massachusetts secure information on identification of insect pests and their control only from qualified professional agricultural entomologists acquainted with Federal and State regulations on the use of pesticides and assigned official responsibility for pest control on floricultural crops under greenhouse conditions.

This manual consists of two sections. The first section will contain a description of the major pests of floricultural crops, their biology, and the damage they cause. This will be followed by general information and the methodology for using pesticides effectively and safely. The second section will provide information on the control of pests on specific crops and will be updated periodically. A table of contents is provided to help the reader locate the desired information.

The following sources of information were utilized in the preparation of this manual:

U.S.D.A. Bulletins, EPA publications on Pesticide Use Regulations and EPA funded Pesticide Applicators Training Manuals.

Experiment Station and Extension Bulletins and Manuals on agricultural pests and their control from the States of Massachusetts, Michigan, North Carolina, California, New York, Pennsylvania, New Jersey, Ohio, and Ontario (Canada).

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Borror, D.J., D.M. DeLong and C.A. Triplehorn. 1976 (4th ed.) An Introduction to the Study of Insects. New York: Holt, Rinehart and Winston, 852 pp.; illus.

Swan, A.W. and C.S. Papp. 1972. The Common Insects of North America. New York: Harper and Row, 750 pp.; illus.

Common Names of Insects Approved by the Entomological Society of America. Entomol. Soc. Amer., College Park, Maryland, December 1970. 36 pp.

A Manual of Conversion Tables, Equivalents, and Dosage Calculations. H.T. Streu. College of Agriculture and Environmental Science, Rutgers - The State University of New Jersey.

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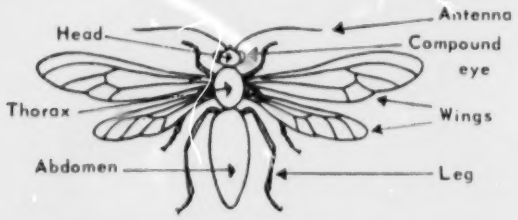
TABLE OF CONTENTS

Preface 1
Characteristics of an Insect 3
The Development of Insects 4-5
Descriptions and Habits of Major Greenhouse Pests and Damage They Cause 5-26
Aphids 5
Cotton or Melon Aphid 5
Chrysanthemum Aphid 5
Foxglove Aphid 5
Green Peach Aphid 5
Potato Aphid 5
Purple-Spotted Lily Aphid 6
Tulip Bulb or Iris Root Aphid 6
Beet Armyworm 6
Bulb Flies 7
Cockroaches 7
Brown Banded Cockroach 7
German Cockroach 7
American Cockroach 7
Oriental Cockroach 7
Corn Earworm 8
Cutworms 8-9
Variegated Cutworm 9
Black Cutworm 9
Dingy Cutworm 9
Bronzed Cutworm 9
Spotted Cutworm 9
European Corn Borer 9
European Earwig 10
Garden Symphilid or Symphylan 10
Fungus Gnats 10-11
Shorefly 11
Greenhouse Leaf Tier 11-12
Leaf Miners 12
Serpentine Leaf Miner 12
Chrysanthemum Leaf Miner 12
Leaf Rollers 12
Oblique-Banded Leaf Roller 12
Omnivorous Leaf Roller 12
Loopers 13
Cabbage Looper 13
Mealybugs 13
Mealybug Species Which Infest Aerial Plant Parts 13
Citrus Mealybug 14
Baker's Mealybug 14
Long-Tailed Mealybug 14
Citrophilus Mealybug 14
Subterranean Species of Mealybugs 14
Midges 14-15
Chrysanthemum Gall Midge 14-15
Rose Midge 15
Millipedes 15-16
Greenhouse Millipede 15-16
Mites 16
Cyclamen Mite 16
Broad Mite 17
Bulb Mite 17-18
Carnation Bud Rot Mite 18
Carnation Shoot Mite 18
Green Two-Spotted Mite 18-19
Pillbugs and Sowbugs 19
Plume Moths 19-20
Scale Insects 20
Armored Scales 20
Ivy or Oleander Scale 20
Florida Red Scale 20
Boisduval Scale 20
Cactus Scale 20
Rose Scale 20
Fern Scale 20
Greedy Scale 20
Unarmored Scales 21
Brown Soft Scale 21
Hemispherical Scale 21
Slugs and Snails 21-22
Springtails 22
Tarnished Plant Bug 22-23
Termites 23
Thrips 23-24
Onion Thrips 24
Easter Flower Thrips 24
Gladiolus Thrips 24
Greenhouse Thrips 24
Weevils: Black Vine Weevil 25
Whiteflies 25-26
Pest Control Methodology Under Greenhouse Conditions 26-27
Exclusion and Sanitation 26-27
Hot Water Sterilization of Bulbs, Corm, and other storage roots 27
Materials and Methods for Pre-Plant Soil Treatment and Sterilization 27
Disinfectants for Pots, Benches, and Equipment 28-29
Biological Pest Control 28
Chemical Pest Control 28-29
Pesticide Formulations and Methods of Application 29-30
Dust and Sprays 29-30
Aerosols 30
Fogs 30
Smokes 30
Soil Applications 30
Timing of Pesticide Applications 31
Compatibility of Pesticides 31
Phytotoxicity of Pesticides 31
Care of Equipment 31
Safety Precautions 31
Gloves 31
Coveralls 32
Boots 32
Head and Neck Coverings 32
Goggles or Face Shield 32
Respirators 32
Common Sense Safety Rules 32-33
Storage of Pesticides 33
Shelf Life of Pesticides 33
Pesticide Disposal 33-34
Cholinesterase Tests 34
Pesticide Delivery Calculations 34
Methods for Calculating Greenhouse Air Volume 34-35
Dilution Tables for Pesticides 35-36
Equivalents Helpful for the Measurement of Small Quantities of Liquid Material 36
Application Rates of Active Ingredients Per Acre for Various Concentrations of Emulsifiables, Wettables, and Dusts 37
The Metric System 38
Useful Conversion Factors for Common Measurement Units 39
The Safe Use of Temik 40-41
A Method of Delivery for Small Amounts of Temik Granules 41
Toxicity of Pesticides 42-44
Categories of Toxicity 42-44
Reported Phytotoxicity of Acaricides and Insecticides to Ornamentals 45-52
Poison Control Centers ..... Inside Back Cover

CHARACTERISTICS OF AN INSECT

There are several external structural characteristics which distinguish insects from other arthropods (lower animals with articulated legs and other appendages). First, an insect has three distinct body divisions - the head, the thorax or middle section, and the abdomen. The head of the insect bears the eyes, antennae and mouth parts; the thorax bears the legs and wings; the abdomen is usually devoid of legs in the adults and bears the reproductive or copulatory appendages. As a rule, the adult insects have three pairs of legs, and if endowed with wings they may have one or two pairs. These characteristics readily distinguish insects from the adults of other types of arthropods such as mites and spiders which have four pairs of legs and no wings.

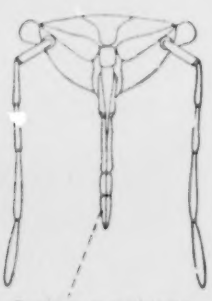


Body parts of an insect.

The following additional organs may be found on each of the above body divisions:

HEAD - Most adult insects have one pair of large compound eyes made up of hexagonal facets. In addition to the compound eyes, there are usually three *"ocelli"*, or simple eyes. These are located on the upper part of the head, between the pair of compound eyes. The antennae, or feelers are located in front of the compound eyes.

Insects of agricultural importance have mouthparts structured to satisfy their feeding habits. The following are, in general terms, typical examples of mouthparts to be found in these insects. The chewing insects have mouthparts designed to bite and grind (beetles, caterpillars, etc.). These mouthparts include an upper and lower lip, a pair of jaw-like structures known as mandibles, operated by strong muscles, and a second pair of weaker jaw-like structures known as maxillae. Organs for smell and taste may be located on smaller appendages (palpi) attached to the maxillae and to the upper lip. Mandibles and maxillae have side to side movement for grasping, gouging and grinding the food. The sucking types of mouthparts may have a long and slender beak (aphids, stinkbugs, scale insects, etc.) or a coiling proboscis (moths and butterflies). The mandibles and maxillae of the former insects are modified into stylets housed in the elongated lower lips and capable of piercing plant's tissue and withdrawing sap. For moths and butterflies feeding on flower nectar the maxillae are modified into a siphoning-sucking proboscis. In the house fly and related non-biting species the lower lip is modified into a sponging-lapping organ.



Sucking mouthparts.

Siphoning mouthparts.

Chewing mouthparts.

Lapping-sponging mouthparts.

THORAX - This body division is subdivided into three sections. The first section, or prothorax, is just behind the head. The second section, or mesothorax, is next. In winged forms it bears the forewings. The last section, or metathorax, bears the hindwings, if present. If only one pair of wings is present, it will be attached to the mesothorax. Each of the three sections of the thorax bears one pair of jointed legs, for a total of six legs. The way in which insects' legs are constructed and jointed may enable them to walk, jump or hop.

ABDOMEN - This is the third and last section of the body. It never bears wings nor true legs (the abdominal legs of caterpillars, sawflies, etc. are called prolegs, hence are not true legs). At the end of the abdomen in the adult female insect there is a structure called the ovipositor, which is the egg-laying apparatus. It is sometimes specialized so that it is capable of boring holes or sawing slits in the plant tissues (thrips, tarnish plant bug, etc.) into which the eggs will be inserted.

Insects breathe through openings along the sides of their bodies known as spiracles. The spiracles open into a network of tubes called tracheae which are internal structures which have a function similar to that of lungs in higher animals.

The above description of the basic structural characteristics of insects should make it possible for the reader to distinguish an insect pest from other plant pests referred to in the text.

THE DEVELOPMENT OF INSECTS

Some insect pests of ornamentals are born alive and immature (aphids, some scale insects, etc.). The majority, however, hatch from eggs. The stages through which insects go while developing from egg or young to adult are collectively known as metamorphosis (change of structure).

In some of the more primitive forms of insects, there is little change in external body structure except for a gradual increase in size from the young to the adult insect. Springtails and firebrats are examples of insects without metamorphosis.

Most insects, however, go through one of three possible types of metamorphic development; gradual, incomplete or complete, characterized as follows:

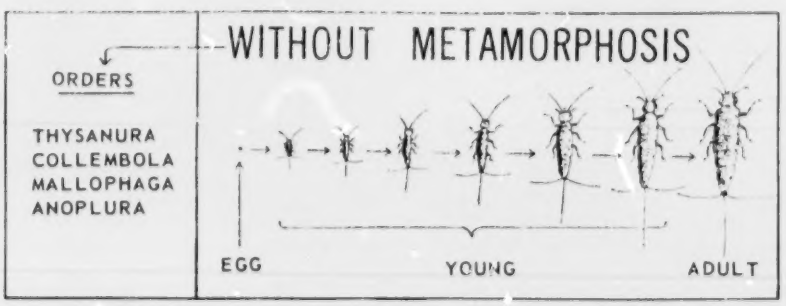
GRADUAL METAMORPHOSIS: After hatching from an egg or being born alive the young goes through only slight external body changes before reaching adulthood. The young insect, called a nymph, resembles the adult except for size and for lack of wings. Through a series of steps called instars the insect develops to full maturity. At the end of each instar the nymph molts its old shell. In winged species or forms, the last two nymphal instars present outside wing pads or wing stubs. The nymphs, as a rule, are found in the same habitat as the adults, feeding on the same host plants. Examples of insects with gradual metamorphosis are grasshoppers, leafhoppers, roaches, tarnished plant bugs, aphids, etc.

INCOMPLETE METAMORPHOSIS: This development is also gradual, but the young, called naiads, are strikingly different from the adult in appearance and habits. They are aquatic, with gill structures which are lost in the adults. The young and adult stages of some of these insects are of importance as predators of other insects. Examples of such insects are the dragonflies, damselflies, and mayflies.

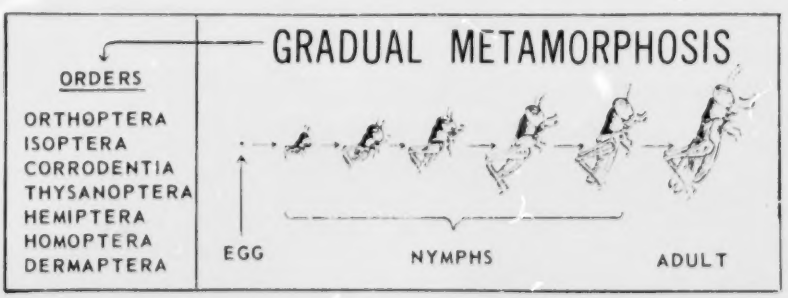
COMPLETE METAMORPHOSIS: Insects such as beetles, bees, ants, flies, butterflies and moths all go through a complete metamorphosis. In this type of development the changes which occur between the egg and adult stages are very marked. The young, called larvae, do not resemble the adults. Features such as mouthparts, legs, antennae, shape of body, as well as feeding habits, differ greatly in the adult and the larva. For example, a caterpillar is the larval stage of a moth or of a butterfly; a grub is the larva of a beetle; a maggot is the larva of a fly. Between the larval stage and the adult, these insects have an intermediate stage called "pupa". This may be naked or enclosed in a silken cocoon or in a hard case (puparium of flies). During the pupal stage the insect does not feed but undergoes drastic external and internal changes (inclusive of internal wing development) culminating with the emergence of a butterfly from what was once a caterpillar, a beetle from a grub, a fly from a maggot, etc.

As a general rule the young and the adult stages of insects with complete metamorphosis have different feeding habits and therefore may be found in different habitats or on different parts of the host plant. During egg laying the adult is found on the host plant on which the larva feeds. Major exceptions to this rule are offered by scale insects, white flies and thrips whose atypical metamorphoses present developmental stages with characteristics reminiscent of the gradual and complete metamorphoses. Knowledge of the type of metamorphosis as well as of the appearance and habits of all the stages of development of a given plant pest is necessary for the proper selection and application of means of control.

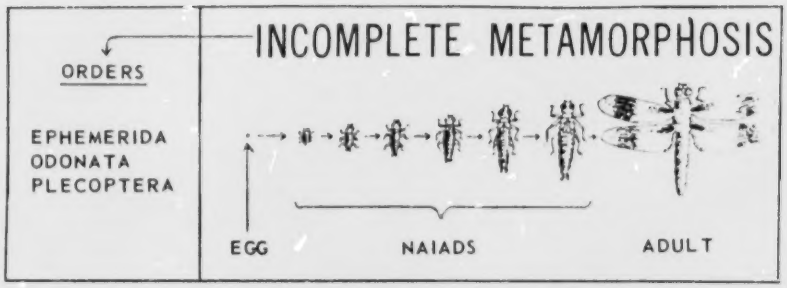
In GROUP 1 the insect that comes from the egg looks exactly like it will when grown, except that it will then be larger.



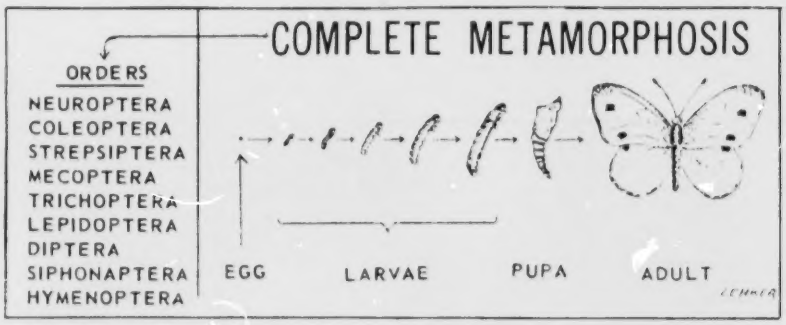
Insects in GROUP 2 change shape gradually. There are three stages of growth, each looking more like an adult.



The young insects in GROUP 3 change shape gradually. They do not look like adults until shedding their last skin. Then there is a quick change.



All insects in GROUP 4 go through four stages of growth. None of the young looks like the adult. There is a great change in shape when the adult emerges from the pupal stage.



DESCRIPTIONS AND HABITS OF MAJOR GREENHOUSE PESTS AND DAMAGE THEY CAUSE

APHIDS

Aphids, generally less than 1/8 inch long, usually occur in large colonies on new growth, at the base of buds and on the undersside of leaves. In addition to sucking the plant juices and distorting growth, they excrete honeydew, which attracts ants and promotes unsightly sooty fungal growth. They also transmit a number of viral diseases. [*Most aphid species found in greenhouses do not mate. The virgin females, winged or wingless, may give birth to 60-100 living young [nymphs] per day for a period of 20 to 30 days. A newly born nymph begins to reproduce as a virgin female in about 7 to 10 days. Winged females appear when the colony becomes overcrowded or the food supply becomes depleted, and migrate to new host plants. The appearance of true sex forms, which mate and lay eggs, usually occurs outdoors with the beginning of cold weather. The egg is usually the outdoor overwintering stage.*]

IMPORTANT GREENHOUSE SPECIES: (Secure the expertise of a specialist for critical identification of aphid species.)

Apterous (wingless) aphid.

The COTTON or MELON APHID, *Aphis gossypii* Glover, is small, 1/16 inch in length and round. It is greenish yellow to very dark green, with black mottling and short dark cornicles (a pair of tube-like structures - one on each side of posterior end). This species feeds on a large number of plants.

The CHRYSANTHEMUM APHID, *Macrosiphoniella sanborni* (Gillette), is slender and shiny dark brown to black with short bottle-shaped cornicles, and mainly infests chrysanthemums.

The FOXGLOVE APHID, *Acyrthosiphon solani* (Kaltenback), is dark green with a dark ring around the cornicles and larger than all other species described here. It feeds on many greenhouse plants.

The GREEN PEACH APHID, *Myzus persicae* (Sulzer): Wingless forms uniformly yellowish green in summer; pink to red in fall and spring. Winged forms brown with a large and irregular dusky blotch on the yellowish abdomen. This is the most common pest of greenhouse plants.

The POTATO APHID, *Macrosiphum euphorbiae* (Thomas), is pink or green, the latter with a darker stripe down the back. The cornicles are large with black ends. Roses and many other ornamentals are susceptible to this aphid.

Winged and wingless forms of green peach aphid.

The PURPLE-SPOTTED LILY APHID, *Macrosiphum lilii* (Monell), is yellow-green with a horseshoe-shaped purple patch on its back. It feeds on lilies, tulips and numerous other plants.

The TULIP BULB APHID, or IRIS ROOT APHID, *Dysaphis tulipae* (Fonscolombe), is similar in color to the cotton or melon aphid, except that wingless forms are covered with a white and powdery wax-like material. This aphid is usually imported into Massachusetts with infested plant material. It feeds mainly under leaf sheaths at the base of plants and bulbs. It is particularly injurious to bulbs in storage. Plants from injured bulbs are distorted and unproductive.

Wingless forms of many aphid species may be easily introduced into greenhouses by means of infested plant material. The winged females have easy access from the outdoors into greenhouses through open vents and give rise to a continuous population build-up on cultivated plants, as well as on weeds if present. A good control program requires continuous surveillance to eliminate initial aphid infestations on the host plants before they reach blossom and/or marketing stages, thus making unnecessary pesticide applications which may be injurious to open blossoms and hazardous to the consumer.

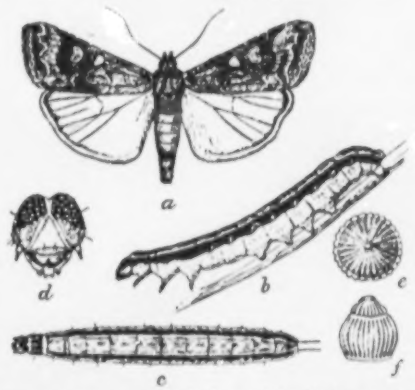
Whenever possible, the grower should gather together in one greenhouse the plant material most susceptible to aphid infestations. A preventative aphid control program is practically and economically more justifiable in this case.

The habit of young aphids to seek shelter between scales of leaf buds, flower buds, etc., places them out of reach of fumigants and contact pesticides. Therefore, it may be necessary to make repeated and thorough applications. Coverage of plant parts with wettable and suspensible powder formulations may be improved with the aid of proper surfactants. Fumigation with selected pesticides can be more effective and less phytotoxic to plants in the blossom stage. Fumigation is also preferable when proper coverage of the foliage canopy cannot be achieved with contact sprays. (See section on fumigation for proper methodology.) The systemic aphicides applied to the soil as granules or drenches or as foliar sprays are still the most popular and widely used. Their indiscriminate and/or continuous use often leads to build-up of resistance among the aphid populations. We still have much to learn on the most effective use of systemic aphicides under greenhouse conditions, especially in relation to the ability of the different growth stages of the host plant to take up and translocate adequate aphicidal concentrations of the systemic pesticides. Insect growth regulators (chemical analogs of natural insect hormones) are presently being evaluated as aphicides. Another aspect of aphid control still in need of additional experimentation concerns a more efficient and economical method of delivery of pesticides in greenhouses. The mechanical devices and corresponding use methodology presently available are badly in need of improvement.

BEET ARMYWORM

Spodoptera exiqua (Hübner): The larva is 1-1/2 inches long; its color varies from olive green to very dark green, nearly black, with a dark stripe down the back and a yellow stripe dotted with pink on each side of the body. It is sluggish and curls into a ball when disturbed. The adult is a moth having front wings that are mottled grey or dusky in color with a wingspread of 1 to 1-1/4 inches.

The eggs are laid in groups and are covered with body hair by the female. The egg is ridged longitudinally and has a characteristic terminal cap which is separated from the rest of the egg by a white ring. A generation may be completed in approximately a month under greenhouse conditions. Pupation takes place in the soil. The insect may reproduce continuously under greenhouse conditions. Its biological cycle is still not completely known.



Beet armyworm: a, moth; b, larva, lateral view; c, larva, dorsal view; d, head of larva; e, egg, viewed from above; f, egg, from side. (After Chittenden)

The damage caused by this destructive pest may go unobserved until it becomes irreparable. Under greenhouse conditions the larva may damage chrysanthemums, carnations, snapdragons, cyclamen, geraniums, and several other ornamentals. Nearly circular patches of leaf tissue up to one inch in diameter are eaten by the larvae, which often leave the transparent lower or upper pellicle intact. Flower buds and flowers may be destroyed or severely distorted. Visual detection of the larvae on the host plants is difficult. Brisk tapping of foliage over a flat clean surface will dislodge the sluggish worms and facilitate detection.

The beet armyworm is not a pest of outdoor crops in Massachusetts. All greenhouse infestations detected thus far have originated from infested plant material imported from other states. In states with inadequate quarantine regulations this problem is more acute.

BULB FLIES

Several species among this group of insects may attack bulbs but the NARCISSUS BULB FLY, *Merodon equestris* (Fabricius) is particularly injurious in greenhouses, where it is usually introduced with infested bulbs. These ordinarily contain one maggot which usually overwinters in the stored bulbs. The center of the infested bulb containing the maggot often becomes a cavity filled with brown decayed tissue and the bulb becomes unduly soft. The infested bulbs either fail to develop aerial parts or produce distorted and unproductive plants.

Bulb damaged by maggot of narcissus bulb fly.

Narcissus bulb fly: adult.

The fly resembles a small bumble bee. It is stocky, 1/3 to 1/2 inch long, and densely covered with yellowish hairs, often with a black band across the middle. The larva is a large maggot, fleshy, whitish to grayish, without legs and with a short brown tube at the back end. It may reach 3/4 inch in length.

Since disinfestation of the bulbs at the time of forcing is usually unsatisfactory, the control of the fly and its maggot should be carried on prior to storage of the bulbs. The greenhouse forcer should therefore always secure pest-free bulbs from the supplier.

COCKROACHES

These insects may injure plants by feeding on terminal buds and other tender growing parts and may be introduced into human habitations, hospitals, etc., via infested plant material. They hide during the day under flats, plastic covers, boards, etc. and feed at night. The following species may occur in Massachusetts:

The BROWN BANDED ROACH, *Supella supellectillium* (Serville), and the GERMAN ROACH, *Blattella germanica* (Linnaeus), are both small and brownish yellow, under 1/2 inch in length. The "German roach" has 2 dark, narrow bands lengthwise on the shield behind the head. The "Brown-banded roach" has one dark broad center band on the shield and often 2 transverse brown bands on the front wings.

The AMERICAN COCKROACH, *Periplaneta americana* (Linnaeus), is large, brownish yellow and up to 2 inches long. The wings cover the entire abdomen. This species is particularly injurious to plants in greenhouses.

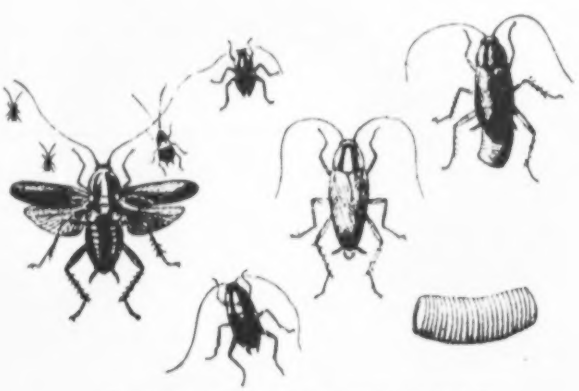
The ORIENTAL COCKROACH, *Blatta orientalis* Linnaeus, is large, black and up to 1-1/4 inches long. The female has short wing pads; the male has wings extending part way down the abdomen.

The life histories of the above species differ as follows:

The "American", the "Oriental", and the "Brown-banded" cockroaches: The female of these three species lays eggs in an egg case which she drops or glues to hiding places. The "American roach" may produce up to 50 egg cases, each containing up to 15 eggs, which will hatch in approximately 40 days. The nymphal stage may last up to 300 days; the adult female may live up to 400 days. The "Brown-banded" roach has a shorter life span, egg laying occurs at approximately 100 days after hatching, and the adult female may live up to 150 days. A female may produce 15 egg cases, each containing 15 eggs hatching in 70 days. The "Oriental cockroach" has a life span similar to that of the "American roach", but it is less prolific. A female may produce approximately 10 egg capsules, each containing approximately 15 eggs hatching in about 60 days.

The "German roach" becomes an adult in 90 days. The female may produce 5 egg capsules. Each capsule, containing approximately 30 eggs which hatch in about 30 days, is carried by the female almost up to the time of hatching. The adult female may live up to 200 days. This is the most prolific of the 4 species and the worst pest of human habitations in New England.

In addition to the chemical control methods given later in this manual, the exclusion of roaches from greenhouse premises by securing pest free material, as well as by implementing general sanitation measures, is strongly recommended. (See also SLUGS and SNAILS.)

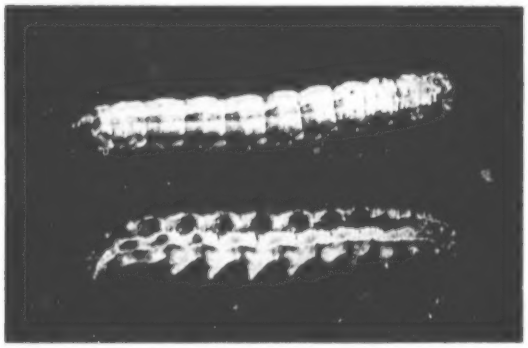


German roach; egg case, nymphs, and adults.

CORN EARWORM

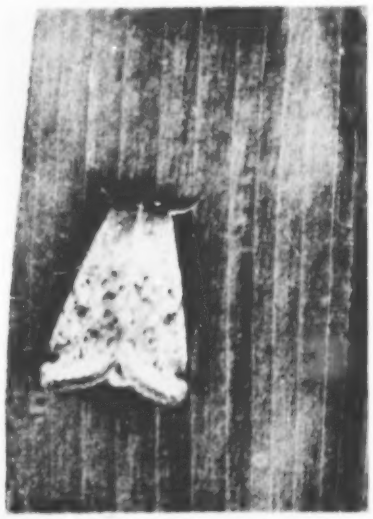
Heliothis zea (Boddie): This insect becomes troublesome in Massachusetts from mid-July to late September and apparently migrates to this area annually from southern states. Some hibernation may occur in Massachusetts during unseasonably warm winters. This is not a pest commonly found in greenhouses, but it may become troublesome if severe outbreaks occur outdoors.

The voracious caterpillars may be green, brown, or pink, with dark and light stripes and a yellowish brown head, and up to 2 inches in length. The stocky and hairy moth is a strong flyer and has a wing span of 1-3/4 inches. The forewings are straw-colored, variegated with black near hind margins, and have a conspicuous black roundish area in the center. The hind wings are cream-colored, with a dark band along the hind margin. The adult when at rest has a triangular outline.



Larvae of corn earworm.

The larvae feed on all succulent plant parts above ground level with preference for buds and flowers of chrysanthemums, roses, gladioli, etc. Young larvae work their way into plant parts and may be overlooked. The moth flies at dusk and feeds on flower nectar.



Moth of corn earworm.

The female may produce an average of 1000 eggs which are laid singly and are the size of a pinhead. They are whitish and hemispherical with ridges along the sides, thus resembling minute sea urchins. The eggs hatch in 2 to 10 days. The larval development is completed after five molts in approximately 2 to 4 weeks. The mature larvae burrow 3-5 inches into the ground, where they transform into smooth brown pupae nearly 1 inch in length and emerge as adults in 2-3 weeks. The moth emerges from the earthen pupal cell through an emergence channel.

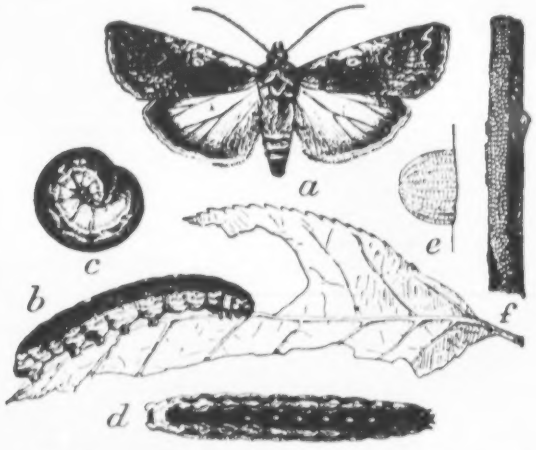
This pest, like other night flying insects, may be excluded from greenhouses by screening the vents if feasible, especially where night illumination of greenhouses is practiced.

CUTWORMS

The caterpillars are usually soft, dull colored, smooth and fat, and 1-2 inches long; they curl up into a ball when disturbed. Adults are somber colored, stocky, and hairy; wings held at rest give the insect a triangular outline. The forewings have a spread of approximately 1½ inches and are dark brown, streaked or mottled with various shades of yellow, brown or copper, gray or black; the hind wings are light in color and not distinctly marked.

Several species are injurious because their caterpillars chew the plants off at soil level or climb to higher plant levels and feed on buds and shoots. They usually feed at night and hide in the soil and debris during the day. Some species are common in greenhouses during spring and summer. The adults are night fliers, and are attracted to artificial light.

The migration of cutworm larvae from sod, soil or weedy areas to greenhouses may be prevented by means of chemical barriers or poisoned baits where feasible. Soil sterilization will eliminate larvae or pupae accidentally introduced into the greenhouse. The screening of vents, if feasible, may exclude the moths from the greenhouse. Chemical control of larval populations established in greenhouses may require drenching the soil at the base of the plants and/or broadcasting poisonous bait. Periodic fumigation will help eliminate the egg laying moths.



Variegated cutworm: a, moth; b, c, d, larvae; e, egg; f, egg mass.

Poisoned bait
Eggs
Cutworm Moths
The fullgrown cutworm burrows into the soil and changes to a pupa from which a moth emerges in late summer.
Pupa
The moths lay eggs on grasses or weeds. The eggs soon hatch and the young worms from them feed on the same plants or almost any late crop till nearly fullgrown. In late fall they bury themselves deep in the ground for protection during winter. In spring they emerge and attack most any young and tender plants they find at the surface.
Plant protected from cutworms by POISONED BAIT. The worms feed at night and will usually hide in the ground or under rubbish before they die.

Biological cycle of cutworm under outdoor conditions.

The VARIEGATED CUTWORM, *Peridroma saucia* (Hübner): This is the most destructive species in greenhouses. The caterpillar is 1-1/2 inches long when fully grown, has smooth skin, gray to brown, with dark markings, a series of yellow dots down the middle of the back, one on each body segment, and a dark "W" on the 8th segment.

The eggs are laid in masses and often in rows of up to 60 or more on twigs, leaves, posts, etc. A female may lay 500 or more eggs. The insect overwinters as a pupa outdoors. The moths or millers emerging in the spring and summer may enter greenhouses through open vents, etc., especially at night.

The BLACK CUTWORM, (also called the Greasy Cutworm), *Agrotis ypsilon* (Hufnagel): The larva is up to 2.8 inches long; it is greasy gray to brown dorsally with faint longitudinal pale stripes. It has the pronounced habit of cutting plants at the soil line.

The insect lays its eggs singly or a few together. It overwinters outdoors as a larva or pupa.

Other species that may occur in the greenhouse are:

The DINGY CUTWORM, *Feltia subgothica* (Haworth): The larva is dingy brown with buff gray triangular areas on each body segment and a dark stripe on each side.

This species has a climbing habit. It overwinters outdoors as a larva. Eggs are usually laid singly.

The BRONZED CUTWORM, *Nephelodes emmedonius* (Cramer): The larva is bronzy brown with 5 pale dorsal stripes running from head to tail.

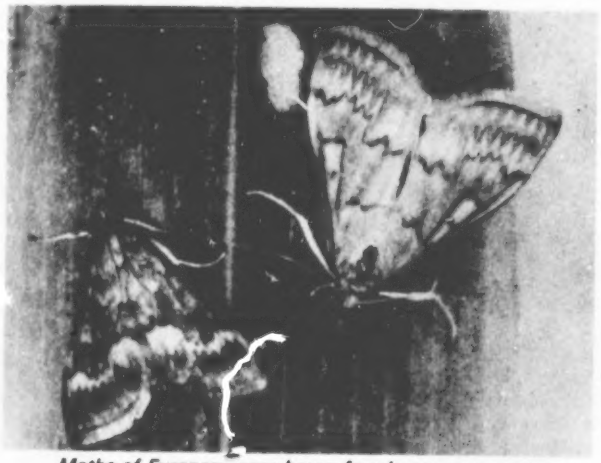
The SPOTTED CUTWORM, *Amathes c-nigrum* (Linnaeus): The larva is grayish brown or blackish, (sometimes olive in color during the summer season) with characteristic wedge-shaped black spots on the upper side of each body segment, larger and closer together towards the posterior end.

EUROPEAN CORN BORER

Ostrinia nubilalis (Hübner): The adults of this insect may enter greenhouses, especially in late summer, through open vents. The larvae injure a large number of plants mainly by boring into the stems. The mature larva is one inch long and greyish to pinkish in color, with a black or dark brown head and two dark spots on top of each body segment. The adult female is a small moth with a wing spread of one inch. At rest, it has a triangular shape. The wing color of the female is yellowish brown to tan with dark wavy bands across the tail end of the front wings. The male has dark brown wings with dark and pale wavy lines and bands at the tail end of the front wings.

The insect hibernates outdoors as a fully grown larva, mostly in plant stalks. The hibernating larva pupates in the spring. The adults emerge in early June and are night fliers. The eggs are laid overlapping, shingle-like, on the underside of leaves in small bare clusters. Under Massachusetts conditions, the insect completes one full generation [June to July] and a partial second [July to September], the latter ending with the overwintering mature larva.

The screening of vents may prevent adult migration into greenhouses. Chemical control should be aimed at eliminating the small larvae before they penetrate into the host plant stalk or tissue.



Moths of European corn borer: female near egg mass.

Corn borer larva in stem of chrysanthemum.

EUROPEAN EARWIG

Forficula auricularia (Linnaeus): This insect is reddish brown and up to ¾ inch in length, with short leathery forewings and long membranous hindwings which fold under the front pair. The insect is a night feeder. During daylight hours, it hides under trash, boards, and among flower petals, leaves, etc. It feeds on insects, organic matter, and living plant parts. It can fly only by taking off from a high place. The male has a pair of curved pincers at the tail end, the female has straight pincers.

The female lays an average of 30 eggs. The nymphs reach maturity in about 68 days. Adults and eggs hibernate outdoors. Under greenhouse conditions the insect is continuously active.

The control of this pest may be achieved by chemical means, by proper sanitation in the greenhouse, and by avoiding the introduction of infested soil, plant material and equipment.

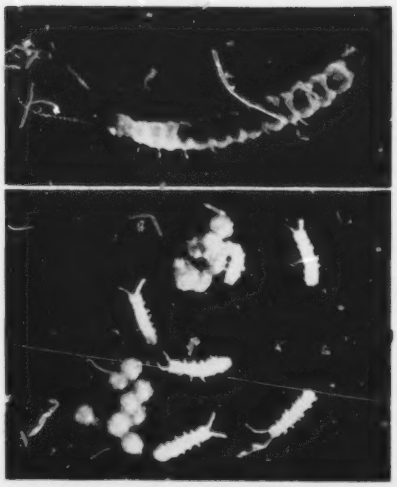
European earwig: male at left.

GARDEN SYMPHILID or SYMPHYLAN

Scutigerella immaculata (Newport): This pest is not to be confused with the true centipede, (Class Chilopoda) which is not a plant pest but feeds on insects, spiders, etc. Nor is the "garden symphilid" to be confused with springtails (which are insects) nor with millipedes (Class Diplopoda) which are described later in this manual. The "garden symphilid" belongs to the Class Symphyla. This class of animals usually has 15 body segments and 10 to 12 pairs of legs. The young add body segments (10 to 15) and legs (from 6 to 12) as they mature. The adult is whitish and approximately ¼ inch long. It has well developed long antennae, always in motion, no eyes and two short fleshy appendages at the tail end.

The eggs are laid in clusters of 12 to 20 in soil crevices. The young may reach adulthood in 3 to 6 weeks.

The symphilids prefer humid soil, rich in organic matter. They are mostly subterranean in habit and in drier beds may be found 3 or 4 feet below soil surface. Their movement in soil is dependent upon the occurrence of natural crevices as well as tunnels and cavities, mostly left by decaying roots of plants. These cavities often are lined with silk spun by the pest.



Garden symphilid: adult above, eggs and young below.

The garden symphilid may cause severe damage to seedlings and to root systems of plants by destroying the root hairs and by favoring the entrance of disease agents. Soil sterilization, by means of steam fumigation or chemical soil drenches may prove of some value in its control provided the upper soil layer is kept moist to prevent the migration of the pest to the subsoil where it would be beyond the reach of steam and chemicals used for its control. Strict sanitation will exclude this pest from the greenhouse.

FUNGUS GNATS

(Root Gnats), *Bradysia spp.* and *Sciara spp.*: The larva of this group of gnats is white and legless, about ¼ inch long, with a shiny black head. The adult is about 1/8 inch long, slender and delicate, with long legs, a clear pair of wings, long antennae, a tiny head and rounded eyes. Under a magnifying lens, the body and legs of the species most commonly found in greenhouses are a pale brownish yellow, with a darker brown waist and a black head.

The larvae feed on fungi and decaying matter but often injure bulbs, seedlings and plants with succulent stems and roots. The burrowing larva also promotes decay of the plant tissue. The adults become a nuisance when present in large numbers. Their presence is objectionable in habitations, public premises and hospitals. Infested plants and soil may give rise to a continuous emergence of gnats. They make short flights and run rapidly on foliage, soil, windows, etc.

A female may lay up to 300 whitish eggs in clusters of 20 to 30 or more on the surface or in crevices of moist soil rich in organic matter. The egg hatches in about 6 days. The larva may feed for 12 to 14 days, when it transforms into a pupa in a flimsy silken pupal chamber in the soil. The pupal stage may last 5 to 6 days. The life cycle from egg to adult requires approximately 4 weeks. The adults live up to 10 days.

Control of the fungus gnat may be partially achieved by proper drainage and sanitation practices on greenhouse premises, i.e. avoiding accumulations of water and organic matter under benches, etc., assuring proper sterilization of soil, and avoiding introduction of infested materials. Unfortunately, the gnats may migrate to greenhouses from immediately surrounding areas or may be introduced with

sterilized and moist potting soil rich in organic matter which has been left outdoors or in bins or other indoor containers for prolonged periods of time. The gnats may be introduced with infested plant material from local as well as from out of state locations.

Soil drenches or soil applications of granular formulations of pesticides, as control or preventative measures, may become necessary to protect plant material most susceptible to infestation, e.g. geraniums, poinsettia, begonias and bulbs in general, especially when grown in soil rich in organic matter, sphagnum medium, peat pots, etc.

Fungus gnat: note clear wings, long antennae, and long legs.

Shore fly: note dark wings with light areas, stout body, and short antennae.

SHOREFLY

Scatella stagnalis often occurs in greenhouses simultaneously with the fungus gnat and the two insects are often mistaken for each other. The shorefly does not injure plants. The adult shorefly can be distinguished from the fungus gnat by its robust body, very short antennae, shorter legs and dark wings with five roundish light spots.

The adults frequent moist greenhouse soil rich in organic matter where they often congregate in large numbers. The larva has a peculiar breathing tube at the tail end and eight pairs of short prolegs. It breeds in stagnant and strongly saline water to be found in greenhouses as a result of excessive irrigation and soil leaching. The elimination of stagnant water will prevent larval breeding, whereas the adults may be eliminated with fumigation or aerosol applications of pesticides.

GREENHOUSE LEAF TIER

Oeobia rubicalis (Guenée): The larvae of this insect may feed on a number of ornamentals and flower crops grown in greenhouses. The mature light green larva is 3/4 inch long with two black dots on the shield situated behind the head. The dorsal part of the body is marked lengthwise with a median dark green stripe bordered on each side by a greenish-white stripe. The adult is a small moth about 1/2 inch long, triangular in shape when at rest, light brown in color, with front wings crossed by dark wavy lines.

The moth is a mighty flier and whenever it alights it moves around with jerky movements while seeking a protected place. During daylight, the moth rests in protected dark places.

Greenhouse leaf tier: moth and larvae.

Leaf tier damage on chrysanthemum.

The eggs are iridescent in bright sunlight. They are laid in overlapping masses mostly on the underside of leaves. The egg hatches in 10-15 days.

At hatching the larva is creamy white and becomes greenish as it begins to feed. It matures in about 3 weeks. The larvae wriggle when disturbed and drop from silk threads. They web together the food supply and move on when the food is exhausted. The pupa is brown, 1/2 inch long and enclosed in a loose cocoon. The pupal stage lasts up to 3 weeks. Several overlapping generations may occur in the greenhouse.

Pesticide fumigation may be necessary to eliminate the moths from the greenhouse. Spray applications of pesticides may prove more effective if combined with pyrethrum or pyrethroids to irritate the larvae and make them emerge from the feeding nests.

LEAF MINERS

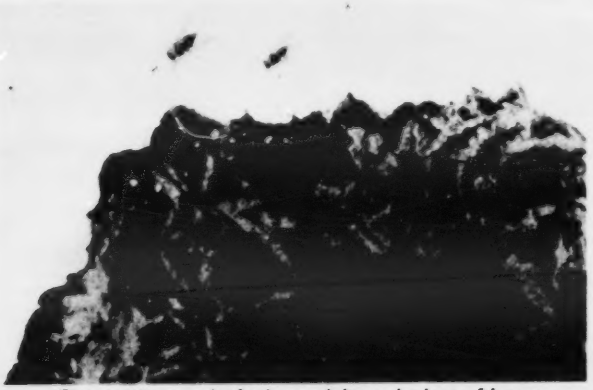
The adults of the most important greenhouse species are small flies about 1/12 inch long, stocky in appearance, and active walkers on foliage. They prefer the apical leaves, where they make feeding and egglaying punctures with their ovipositors. These, as well as probing punctures, give rise to the closely spaced whitish dots seen on plants often prior to the appearance of the mines and also when the infestation has been stopped in its incipient stage.

Each female may lay about 100 eggs during its life span of 2 to 3 weeks. The egg, inserted into the leaf tissue, hatches in 5 to 6 days and give rise to a soft white maggot, approximately 1/10 inch long when mature. The maggot's feeding causes the familiar blotchy or serpentine type mines found mostly in the leaf tissue. This feeding may last up to 2 weeks. The yellow to yellowish brown pupae usually drop to the ground, where they take about 2 weeks to transform into adults.

The following are the most important miners of greenhouse crops:

The SERPENTINE LEAF MINER, *Liriomyza spp.*, are small flies with a blackish body, conspicuous yellow markings, a yellow head, and brown eyes. The larval feeding causes mainly serpentine mines.

The CHRYSANTHEMUM LEAF MINER, *Phytomyza atricornis* Meigen, is a larger fly, uniformly black in color. The larval feeding causes large blotchy mines as well as serpentine mines. In this species pupation may occur in the mines.



Chrysanthemum leaf miner: adults and mines of larvae.

LEAF ROLLERS [also called Bell Moths]

The adult moths have a bell-shaped appearance when at rest and do not exceed 0.6 inch in length. They tie terminal leaves together into a roll and feed on them from the inside. They also bore into flower buds and terminal shoots of a number of flower crops. Once established in the greenhouse, these pests are difficult to eradicate.

The eggs are laid in overlapping masses of 100 or more on leaves and hatch in 7 to 15 days. The larva, when disturbed, wriggles violently backwards or drops by a silk thread. The larvae feed within the webbed-together plant material for 3 to 4 weeks. Pupation takes place in the leaf rolls or buds and may last up to 2 weeks. The female may lay up to 500 eggs, and 2 to 4 generations may occur annually. The adult moths are night fliers.

Moth of oblique-banded leaf roller.

Larvae of oblique-banded leaf roller.

The following are the most important greenhouse species:

The OBLIQUE-BANDED LEAF ROLLER, *Choristoneura rosaceana* (Harris), is a light brown moth with 3 dark brown bands running obliquely across the forewings. The caterpillar is 1/2 inch long, pale green with a black head.

The OMNIVOROUS LEAF ROLLER, *Platinota stultana* Walsingham, is a dark brown moth with long labial palpi protruding in front of the head in the shape of a snout. The newly hatched larvae are yellowish white with brown heads. Mature larvae are about 1/2 inch long, yellowish to brownish green, with a broad, transparent stripe along the middle of the back.

The control of these pests is difficult to achieve, especially when they have become well established in their hideouts. Aerosol applications will help eliminate the moths. The addition of pyrethrins to spray formulations may improve control of the larvae by irritating them and thereby inducing them to leave the protection of the leaf rolls. The screening of vents, proper sanitation measures, and above all careful inspection of plant material are helpful in excluding the pests from the greenhouse.

LOOPERS

The species most commonly found in greenhouses is the CABBAGE LOOPER, *Trichoplusia ni* (Hübner). The larvae measure up to 1-3/8 inches in length, and are pale green in color with white stripes on each side of the body and two dorsal stripes extending the entire length of the body. The diameter of the body tapers from posterior end towards the head. The prolegs on the third and fourth abdominal segments are absent and therefore the caterpillar moves with a looping gait, like a measuring worm. The moth has a wing span of almost 1-1/2 inches. The front wings are dark brown mottled with lighter brown coloration, each wing having, near the center, a silvery spot shaped like an imperfect figure "8". The hind wings are greyish brown with a bronzy shading.

The eggs are the size of mustard seeds and they are laid singly on the host plant's foliage. They are pale green with very elaborate striations on their surface. Hatching occurs in a week to 10 days. The caterpillars feed voraciously for 3 to 4 weeks. Pupation takes place in a transparent white silken cocoon, about 1-1/4 inches long, attached to the surface of leaves. The adult moth emerges in about 2 weeks. The pupal stage is the outdoor hibernating stage in temperate areas.

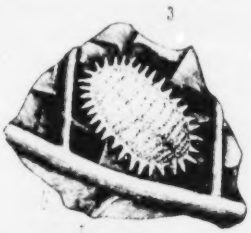
This insect apparently does not hibernate in Northern areas. Its outdoor occurrence in New England begins in late July and is generally ascribed to the yearly migration of adults from Southern areas. Greenhouse infestations are a result of the introduction of infested plant material to the premises and of the migration through open vents of the night flying moths. Winter infestations under greenhouse conditions are not uncommon, especially when plant material is imported from Southern and Western areas of the country. The most serious greenhouse infestations usually occur in New England in the fall of the year. A large number of plant species may be seriously damaged by this insect. All aerial parts of plants may be injured by the voracious caterpillars.

Successful control of this pest may be achieved with the biocontrol agent, *Bacillus thurningiensis*. The screening of greenhouse vents and exclusion of infested material from the premises are also effective control measures.

Cabbage looper: a, larva; b, pupa; c, adult

MEALYBUGS

MEALYBUG SPECIES WHICH INFEST AERIAL PLANT PARTS: These insects are currently among the most serious of greenhouse pests in Massachusetts. They are often introduced into greenhouses with infested plant parts from other states. Nymphs and adult females cause malformation and discoloration of plant organs by injecting toxic saliva into plant tissue and by extracting sap with their needle-like, piercing-sucking mouth parts. Their excretion of large amounts of honey-dew gives rise to the growth of unsightly black sooty mold. This and their copious waxy secretion and cottony egg sacs interfere with the photosynthetic process and also make the plant material unfit for sale.



An adult mealybug.

Generally speaking, mealybugs are soft, segmented, oval insects. The naked body of the adult female is 1/5 to 1/3 inch in length, reddish, usually covered with a whitish, powdery, wax-like material. A fringe of waxy projections of various length are usually present at the margins of the body.

In contrast to scale insects, mealybugs retain the use of their legs throughout their stages of development and are able to migrate from plant to plant. The newly hatched nymphs or crawlers require from 6 weeks to 2 months to reach maturity. The mature female usually dies after egg-laying, which lasts about 10 days. Depending on the species, the mealybug may lay either living young or masses of several hundred yellowish or orange eggs in white cottony sacs. The eggs begin to hatch in about five to ten days, but the unhatched eggs or the young crawlers may linger in the cottony sac for a longer time if environmental conditions are not favorable. A number of species have males which emerge from flimsy, cottony cocoons as delicate two winged fly-like insects. The adult male is short lived and does not feed.

The control of mealybugs becomes difficult when heavy populations become well established on greenhouse plants. Pesticides presently registered for greenhouse use afford mediocre control of these pests. Careful inspection of plant material prior to introduction into the greenhouse may help exclude the pests from the premises. Pest-free certification should be secured for plant material introduced from other states. The control of established populations with spray materials may require the addition of a proper surfactant to wettable powder formulations to counteract the water repellant nature of the waxy secretion of the insect. Insect growth regulators are being evaluated for the control of these pests. The naked crawler is more easily controlled with sprays, fumigants, and aerosols. Secure the cooperation of the Extension Entomologist to eradicate established populations.

The following are the most important greenhouse species:

The CITRUS MEALYBUG: *Planococcus citri* (Risso). This is the most common greenhouse species. The body of the adult female is surrounded by short projections, with the posterior ones about 1/4 the length of the body. With the exception of a narrow bare line down the middle, the body is uniformly covered with wax-like powder. This species may lay up to 500 eggs in irregular cottony masses of white secretion.

Citrus mealybug: adults, nymph, and egg sacs.

The BAKER'S MEALYBUG: *Pseudococcus obscurus* Essig and the GRAPE MEALYBUG, *Pseudococcus maritimus* (Ehrhorn): These species have longer projections at the posterior end, 1/2 as long as the body or longer. These two species are difficult to differentiate because of their similarity in appearance.

The LONG-TAILED MEALYBUG, *Pseudococcus adonidum* (Linnaeus): This species produces living young instead of eggs. The projections around the body are longer than in the above species, the posterior ones being as long or longer than the body length.

The CITROPHILUS MEALYBUG, *Pseudococcus fragilis* Brain: This species may also be found in greenhouses. It may be difficult to differentiate from the citrus mealybug without comparison of microscopic characteristics. The marginal projections surrounding the body are wedge shaped and the posterior projections are longer than those of the citrus mealybug.

SUBTERRANEAN SPECIES OF MEALYBUGS: *Rhizoecus americanus* (Hambleton), *Rhizoecus falcifer* Künckel d'Herculais, *Rhizoecus pritchardi* McKenzie: In this group of mealybugs the number of species cited as ornamental pests is rather large, according to available literature. Generally, these insects are slow moving, sac-like in shape, with pronounced crosswise groove-like lines. They are covered with a fine, powdery, wax-like

Ground mealybug: adults.

material. They do not have the marginal projections or filaments typical of the aerial species. The young are found in soil crevices or chambers coated with white wax-like material. This material may cover extensive areas of the outer surface of the root ball. It is therefore the most evident sign of infestation. The young, upon leaving the egg-laying chambers, feed upon the root system of the host plant, causing stunting and death of aerial parts. The male of these root feeding pests is rarely seen.

Once introduced into the greenhouse, these soil insects may be spread with water leaching through drainage openings of plant containers or benches, by infested soil, plant debris or the use of non-sterile equipment. The mealybugs may also migrate to adjacent uninfested areas by crawling or following the path of plant roots that have grown through the drainage openings of the containers. The newly born nymph is the most active crawling stage.

It is advisable to establish strict sanitary practices to avoid the introduction and distribution of these insects in greenhouses. Premises infested with root mealybugs should be freed of all infested plants and debris, and soil and containers thoroughly disinfested before re-use.

MIDGES

These active insects are delicate, long legged, slender flies, about 1/20 to 1/12 inch in length, with two transparent or faintly smoky broad wings which have 3 to 5 long veins and no cross veins. The larva is fleshy, about 1/12 inch in length, legless and seemingly headless, and yellowish to orange. Its feeding may give rise to galls on leaves and stems. By tunnelling into plant tissue, it may produce malformation and/or death of buds and young shoots.

The eggs are elongated, with rounded tips, yellow to orange. Pupation occurs in the gall or, in the case of tunnelling species, in the soil. The adults are short lived — the male living only a few hours, the female laying eggs soon after fertilization and dying shortly thereafter.

The most important gall forming greenhouse species is the CHRYSANTHEMUM GALL MIDGE, *Diarthronomyia chrysanthemi* Ahlberg. It confines its feeding to chrysanthemums. In the greenhouse, it may complete its life cycle from egg to adult in one month.

The male and female are yellowish to reddish orange. The hatching larvae are greenish, becoming reddish as they mature. The galls on foliage are usually found on the upper surface of the leaves. They are cone-shaped, approximately 1/12 inch in length and irregular in outline.

The adults emerge in early morning. Mating and egg-laying is terminated by mid-morning, after which both sexes die. The female may lay up to 100 reddish eggs in masses or in chains on tender new growth. These hatch 3 to 4 days later. For the first week after hatching, the larvae may escape detection. After a week, galls will form where the larvae have penetrated into the plant tissue. Pupation will occur in the galls 2 to 3 weeks later.

The damage to stems appears mostly as thickening and/or distortions, resulting in stunted growth and death of buds. Young plants, if severely infested, may fail to grow. The conspicuous galls on old plants may render them unfit for sale.

Galls of chrysanthemum gall midge.

The use of organo-phosphates and carbamates has greatly reduced the incidence of this pest; however, careful inspection of incoming plant material must not be lessened. The adults are very sensitive to fumigants and aerosols.

The ROSE MIDGE, *Dasineura rhodophaga* (Coquillett), is a "non-gall forming" species which may prove to be a serious pest in the greenhouse. Roses are the primary hosts of this midge. Flower buds infested by the midge may turn brown to black and die; young shoots may be deformed or killed outright. The adults are yellowish brown, approximately 1/20 inch long and active at night. The larvae are salmon pink.

Rose midge damage on flower buds and young leaves.

Rose midge: adult female.

The short lived female places the barely visible yellowish eggs under sepals of flower buds and between leaves of leaf buds. The maggot feeds on the buds and other succulent parts of the plant. The mature larva drops to the ground to pupate in a silken cocoon in the soil. The adult emerges 7 days later. The life cycle from egg to adult may be completed in 3 weeks. The pupa is the overwintering stage outdoors.

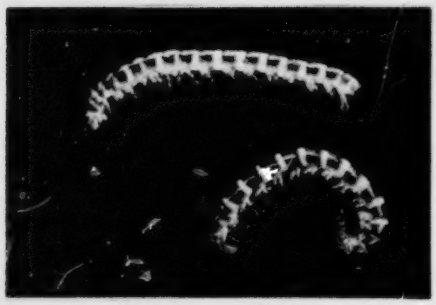
Although pupae may be brought indoors by means of infested soil, infested rose stocks are the primary means of introduction of the pest into greenhouses. Preventive sanitary measures are most helpful in keeping this pest out of the greenhouse. The carbamates and organo-phosphates are also reducing the incidence of the rose midge in greenhouses.

MILLIPEDES

MILLIPEDES (or Myriapods), sometimes called thousand-legged worms, are arthropods belonging to the class Diplopoda — they are not insects! They have 2 body sections: a head with a pair of short antennae, and a body made up of a large number of segments (up to 40 or more), each one really 2 segments fused together, bearing 2 pairs of short legs, with the exception of the first five segments, each of which bears a single pair of legs. Most species have 30 or more pairs of legs. When disturbed, the millipede coils up into a ball and emits an offensive brownish protective fluid. Millipedes do not bite people. They thrive in warm, damp places rich in organic matter, and are nocturnal in habit — during the daytime they remain concealed in soil, under boards, pots, etc.

The GREENHOUSE MILLIPEDE, *Oxidus gracilis* (Koch), may at times become an important pest of ornamentals. It is approximately one inch long, somewhat flattened dorso-ventrally, grayish to chestnut brown to black on top with yellow lateral plates.

The female may lay up to 300 eggs covered with a sticky material in clusters of 20 or more. The hatching young have only 3 pairs of legs. They go through five larval stages, adding segments and legs until mature. There is usually one generation each year.



Greenhouse millipede.

This millipede is a scavenger, feeding on algae, organic matter, sprouting seeds, seedlings, and tender roots of plants. It also disseminates and/or introduces disease organisms.

Clean cultural practices are the most effective control measures against this pest. Equipment, boards, and supplies stored under benches serve as refuges for millipedes. Sterilization of soil and equipment will prevent introduction of the pest into the greenhouse. Manure serves as food for millipedes.

Smaller outdoor species of millipedes, or "common millipedes", which feed mainly on decayed matter and are therefore less harmful to vegetation, may also occur in greenhouses in the Northeast. These species are usually entirely light brown and nearly cylindrical in shape, with less distinct body segmentation. Large numbers of individuals are sometimes seen outdoors on walls of habitations or indoors in wet basements. A number of southern or exotic species of millipedes may be introduced into greenhouses with plant parts, and should be identified only by personnel having proper expertise.

The millipede should not be confused with the "True Centipede", which feeds on insects, spiders, etc. The true centipede belongs to the class Chilopoda and has long antennae and 15 or more pairs of strong legs, one pair per body segment. The legs of the common house centipede, one of the "true centipedes", are quite long. These animals do not curl up into a ball when disturbed, but run rapidly. They possess a pair of poison jaws with which they paralyze their prey. Some southern species are capable of inflicting a painful bite on man. In addition to the house centipede, common in temperate zones, a number of species are found under stones, under bark, in rotten logs, in soil, etc. Poisonous southern species may be introduced into greenhouses with imported plant material.

MITES

This group of arthropods (along with ticks) belongs to the order Acari of the class Arachnida (spiders, scorpions, daddy-long-legs, etc.). Mites are very small animals. In contrast to insects, they are wingless, and the head, thorax, and abdomen appear to be fused together, generally giving the body a compact oval to oblong shape. Sex in many species is determined on the basis of fertilization — males develop from unfertilized eggs, females from fertilized eggs. The newly hatched young, called larvae, have only 3 pairs of legs. The larval stage is followed by 2 nymphal stages — a protonymph and a deutonymph — and by the adult stage. The nymphal and adult stages are endowed with 4 pairs of legs (gall mites have only 2 pairs). All stages do not have antennae. The Acari constitute a large group of animals. Terrestrial and aquatic forms are known. The aquatic forms occur in salt and fresh water. Many species are scavengers; others are external parasites of vertebrates, including man, and invertebrates, including insects. A considerable number of species are plant feeders and cause much damage to agricultural crops with their piercing-sucking mouth parts.

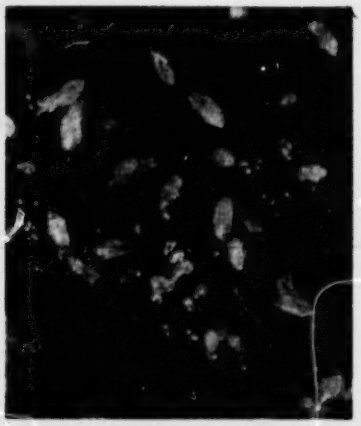
The plant feeders are generally called "Spider Mites". Several species are serious pests of greenhouse ornamentals. They may attack both aerial and underground parts of host plants. The following species are most commonly found in greenhouses in the Northeast.

CYCLAMEN MITE, *Steneotarsonemus pallidus* (Banks): This mite is not more than 1/100 inch in length and usually inflicts heavy damage before it is detected. The grower usually sees the injury, which is sudden and severe, rather than the mite itself, which is nearly microscopic in size. The importance of this mite has been accentuated by the recent increase in popularity of foliage plants. The continuous movement of plant material from temperate and subtropical areas into the Northeast has increased the incidence of this pest, and heavy losses have occurred in greenhouses. The mite has a wide host range. Its development is favored by high relative humidity (80 to 90%) and by temperatures of around 60°F. Severe infestations in the Northeast are often found during fall and winter. The mite prefers to feed and multiply in buds and surrounding young leaves. The damage may appear as blasting of buds, curling of leaflets from the outside inward, and/or wrinkling of leaves so that pockets and pit-like depressions are formed. Flower buds may fail to develop or, if they open, are likely to be distorted. Under the microscope or (with considerable difficulty) with a 10X hand lens, the mite appears minute and semi-transparent, with a greenish tinge. The female moves slowly and is elliptical with 2 stout pairs of front legs, and with slender 3rd and 4th pairs of legs. Each of the two hind legs bears 2 long bristles, the one on the inner side being longer. Males, which are usually outnumbered by females, are nearly square, with the hind pair of legs equipped with claws instead of bristles.

The female may live up to a month, laying 100 or more eggs usually tucked into crevices of buds and young leaves. The eggs are very small, oval, glossy white and unmarked. They hatch in three to seven days. The young larvae are glistening white and move slowly. The entire life cycle is completed in four to six weeks.

Sanitation and preventative chemical control measures are recommended against this pest. Interception of infested plant material may be achieved with the aid of the Extension Entomologist. Pest-free certification of imported material should also be secured.

Distortion of terminal growth of ivy caused by cyclamen mite.



Cyclamen mite: eggs, nymphs, and adults.

BROAD MITE: This mite, *Hemitarsonemus latus* (Banks), is often confused with the cyclamen mite described above. The broad mite can be distinguished from the cyclamen mite by its eggs which show rows of conspicuous white dots on the surface and are laid flattened and exposed on the leaf surface. The adult and larva of the broad mite are smaller and walk rapidly on the host plant. In contrast to the cyclamen mite this pest is favored by high temperatures, 70° to 80°F, and may complete its life cycle in less than a week's time. The mobility of the broad mite favors its rapid distribution within the greenhouse during the period of its maximum reproduction, from spring to early fall. Its feeding is more prevalent on the lower surface of young leaves. The injury prevents normal expansion of the surface and causes a downward puckering of the leaf. Terminal buds may be killed. This mite causes little or no distortion of flowers and flower buds. For sanitation and preventative control, see Cyclamen Mite.

BULB MITE, *Rhizoglyphus echinopus* (Famouze and Robin): This is a serious pest of bulbs, especially of those with loose fleshy scales. The mite feeds upon the bulb's scales, making it possible for bacteria and fungi to invade the injured tissue. Infested bulbs show reddish-brown discoloration on the fleshy scales and frequently rot prior to or after planting. Should the infested bulb grow, the leaves will be stunted, distorted, and soon turn yellow. The flower stalk will be distorted or will fail to develop. This mite infests the bulbs well before they are dug from the soil. Later, in storage at temperatures above 50°F, the mite will continue to multiply and will migrate to other bulbs, thus infesting the entire stored lot. Lightly infested bulbs held in cold storage below 50°F may still become seriously infested during shipment, on store shelves, or after planting, whenever temperature conditions become favorable.

The adult bulb mites are yellowish white, often tinged with pink, with mouth parts and legs a reddish brown. The female is minute — approximately 1/25 inch long. The male is usually smaller — a 10X hand lens is necessary to detect it. The mature forms move around freely. The pest is most active when the humidity is high and the temperature is between 60 and 80°F. At temperatures below 50°F and above 90° the mite becomes torpid.

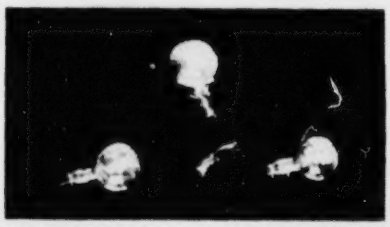
The female may live for about a month, while the male dies soon after mating. The eggs are white, minute and laid singly on the bulbs. They hatch in 2 to 7 days. A female may lay 50 to 100 eggs at the rate of 6 to 8 per day. Under favorable conditions, an entire life cycle may be completed in 2 to 4 weeks. In addition to the larval stage and the 2 nymphal stages mentioned above in the general description of this group of pests, the bulb mite has an additional nymphal stage called the hypopus stage. The mite in this stage is minute, 8-legged, and oval. It is covered with a thick brown cuticle, and is thus well adapted to withstand unfavorable environmental conditions. In this most active stage, the mite is able to wander about and be transported considerable distances by attaching itself to objects and also to insects such as flies visiting the rotted bulbs. The hypopus stage may last up to two weeks and, when a suitable host plant is found, it molts into the deutonymph, which in turn molts into the adult stage.

Bulb mite: various stages of development.

It is the responsibility of the bulb producer to control this mite in the field and prior to storage. The forcer should request that all bulb shipments he receives be accompanied by a pest-free certificate. If the forcer wishes to store the bulbs, the storage area should be properly sanitized and kept at 35 to 40°F. At planting time, the forcer should be certain that the bulbs are sound.

Bulbs which are soft when squeezed should be destroyed at once, preferably burned or placed in boiling water. They should not be allowed to accumulate on the premises. Hot water treatment for preplanting sterilization often weakens the bulbs, and should be used only as a last resort. Bulbs can be dusted with acaricides and fungicides or dipped into solutions of acaricides. In the case of storage or delayed planting, the dipped bulbs should be promptly and properly dried.

CARNATION BUD ROT MITE (or Grass Mite), *Siteroptes graminum* (Reuter): This mite is associated with the fungus of the bud rot of carnations, *Fusarium tricinctum*, which also causes "silver top" of grasses. The mite's movement from bud to bud contributes to the dissemination of the spores of the fungus. The infested buds may retain a healthy appearance, but fail to open or, if they do open, the flower is deformed or lop-sided, with a decayed center. The mite enters only the buds, where it may be found in large numbers, feeding on stamens and pistils, its direct damage to the bud being therefore of minor consequence.



Carnation bud mite: females with distended abdomens.

The adult female, greenish-white and minute prior to mating, becomes flask shaped after mating, and about 1/50 inch long. Its abdomen becomes greatly swollen because of the eggs developing within. The young hatch within the abdomen, which disintegrates, releasing the offspring. Some of these young mites migrate to other buds, carrying the spores of the fungus. Each female may produce about 200 young. Two to three generations per year may occur under greenhouse conditions.

This mite may be kept under control by thoroughly cutting all blossoms as soon as they are ready for market, and by eliminating all culls, infested or suspicious buds, etc., from the growing area and surrounding premises. The elimination of grassy areas adjacent to growing houses and the exclusion from the premises of outdoor grown carnations and unsterilized soil will also help to avoid infestations.

This species should not be confused with the CARNATION SHOOT MITE, *Aceria paradianthi* (Keifer), which lives at the base of new shoots, leaves, stems, and in flower calyces. The infested shoots may have a greasy or dusty appearance, resulting from thousands of minute mites congregated on the shoots. Distortion of foliage, yellowing, stunting of growth, absence of flower buds and presence of excessive basal shoots are also characteristic of the damage caused by this mite. Individual mites are extremely small and difficult to see, even with a 15X hand lens. The buildup of the mite population is slow. The infestation may be spread by means of cuttings and other plant material. Properly timed applications of acaricides will eliminate the pest.

GREEN TWO-SPOTTED MITE

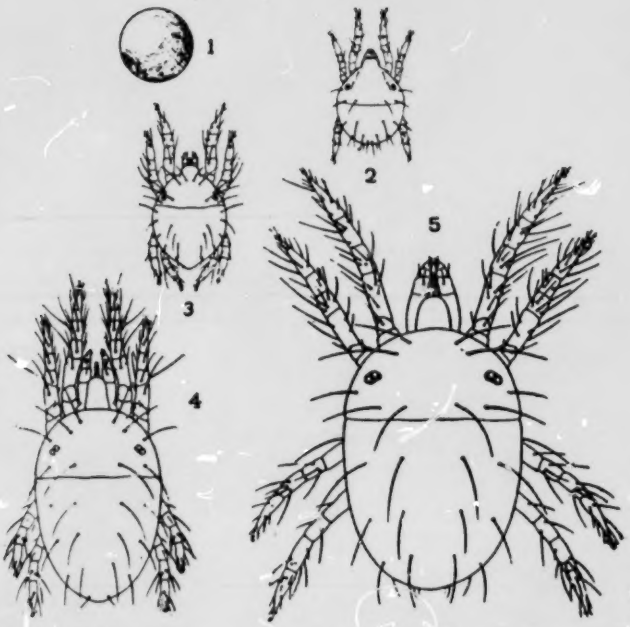
Tetranychus urticae (Koch): This species is most destructive under greenhouse conditions and very few ornamentals escape its ravages. Light infestations cause stippling of leaves, especially of mature ones. Dulling and yellowing of foliage, followed by blasting of buds and flowers may occur as a result of heavy mite infestation.

Webbing of two-spotted spider mite on chrysanthemum.

The webbing of infested plant parts is one of the most characteristic signs of heavy mite infestation. The mite is most prolific at high temperatures and at low humidity, especially during the summer months. At this time its high speed of reproduction may lead to sudden and destructive population explosions.

The adult female is oval, approximately 1/50 inch long, greenish to slightly orange, with 2 black areas and 4 pairs of legs. The male is smaller than the female. This mite prefers the lower surface of leaves, and bud and flower parts that offer protection. The mite spins thin strands of silk that develop into extensive sheets of webbing when the infestation is severe.

The eggs are laid singly, up to 100 per female during her 3 to 4 week life span. Under a hand lens, the eggs appear globular and amber to reddish. The newly hatched larvae and the two nymphal stages are very active feeders. Under optimum greenhouse conditions, the life cycle may be completed in less than 2 weeks.

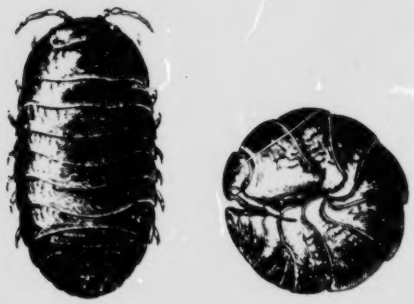


Spider mite: 1, egg; 2, larva; 3, protonymph; 4, deutonymph; 5, adult. (after Ewing)

Continuous vigilance on the part of the grower may prevent costly surprises. The introduction of infested plant material into greenhouses as well as vegetation allowed to grow near the outer perimeter of the greenhouse may give rise to population explosions, especially during the summer months. Infestations usually start and develop most rapidly on plants near steam pipes or other objects which radiate heat. It is much easier for the grower to prevent a mite infestation than to eradicate it once it is established in the greenhouse. With the presently available acaricides, it is practically impossible to control mites established in open blossoms without injuring the saleable product. The effectiveness of presently available acaricides diminishes greatly at high greenhouse temperatures. Resistance of mites to chemical control agents is an ever present problem resulting from the extensive and continuous use of acaricides often related chemically. The feasibility of utilizing predaceous mites (mites that feed on other mites) for the control of this and other mite species that feed on greenhouse plants is presently under study. Growth regulators are also under study for acaricidal efficacy.

PILLBUGS AND SOWBUGS

These animals are crustaceans, not insects. They are related to crabs, shrimp, lobster, etc. They have seven pairs of legs, a pair of antennae, breathing gills, and a back covered by a series of plates. Some species run into hiding when disturbed; others roll into a ball — hence the name "pillbug". They are greyish, flat, and elliptical, not exceeding 1/2 inch in length. They are scavengers as well as plant feeders and may damage roots and tender shoots of greenhouse grown plants. Active at night, these animals hide in soil or under flower pots, rubbish, etc., during the day. An abundance of organic matter and high humidity favor their development.



Greenhouse pillbug: adults.

The adults may live a year or more. They develop from eggs which are kept in a "pouch" on the ventral side of the female. A female may lay up to 75 eggs. The hatching young remain in the pouch until capable of self-care. Completion of development to adulthood requires approximately a year.

These animals may be kept out of the greenhouse by proper sanitation. Soil sterilization, elimination of hiding places, and the sanitation measures indicated for the control of slugs and snails are applicable to pillbugs and sowbugs.

PLUME MOTHS

Platyptilia spp.: Our knowledge of the species of plume moth occurring in the Northeast is incomplete. Only two minor infestations on geraniums have been detected during the past seven years in Massachusetts. They apparently originated from introduced infested plant material. Generally, these insects are most injurious to geraniums and snapdragons. Flower buds, terminal buds, and stems are injured by the feeding larvae.

The adults of these insects have wings split into feather-like divisions, resembling a series of plumes. The front wings usually have two divisions and the hind wings three. The wings are very slender and at rest they are held outstretched horizontally, at right angles to the body, forming a "T". The wing span is about 1 inch. The legs are relatively long, the hind ones longer. The adult is generally tan with scattered greyish to brown spots.

Each female lays up to 200 eggs. They are laid singly on the undersurface of leaves. They hatch approximately 1 week later. The caterpillars reach 1 inch in length and may be yellowish, greenish, or purplish, with a black head and a hairy body. They feed for a month or slightly longer on terminal leaves, buds, and flowers, and may penetrate into stems. They often roll leaves together. Pupation occurs where the larvae have been feeding. The pupa, often enclosed in a leaf roll, is attached to plant parts or other objects with silk threads. Emergence of adults may occur 1 to 2 weeks later. Under greenhouse conditions, the life cycle may be completed in approximately one month. The adult female may live 2 weeks or more.

Plume moth.

These pests are usually introduced into greenhouses with infested plant material and, as in the case of leaf rollers, may pass unobserved until severe damage becomes evident. Their habit of boring into buds and stems and hiding in leaf rolls puts them out of reach of pesticides. The addition of pyrethrins or pyrethroids to spray applications will irritate the larvae and make them abandon their hiding nests.

SCALE INSECTS

These insects are known collectively as coccids (Superfamily Coccoidea). They include the soft or unarmored scales, the armored scales, and the mealybugs. The latter are described in an earlier portion of this manual. The following characteristics are typical of this highly specialized group of insects:

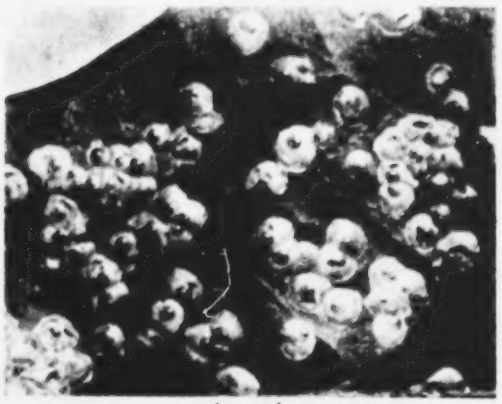
The adult female is sac-like, wingless, and usually legless. Therefore, once settled, it does not wander. The adult male has eyes, legs, antennae, and a single pair of wings. At the rear end, it has one (rarely, two) long, style-like process. The male lacks mouth parts and does not feed. These insects injure plants mainly by sucking sap and by injecting toxic saliva into the plant tissue.

The development of these insects may be summarized as follows. The first instar nymph, also called a "crawler", has legs and antennae and is fairly active. It may travel some distances without feeding for as long as 2 days. Upon finding a suitable site on a host plant, the crawler inserts its sucking mouth parts into the tissue and settles down by folding its legs under its body. After the first molt, the legs and antennae are often lost, and a waxy scale-like covering is secreted to protect the soft body. The scale covering is enlarged with subsequent molts. The female produces eggs or gives birth to young under this scale covering. Three to seven generations may be completed in one year. The male development differs from that of the female in the last instars with the appearance of a pupal stage followed by the winged adult male.

ARMORED SCALES, (Family Diaspidae): This is the largest family of scale insects. The body of the female is unattached to the scale covering, which is formed of wax secretion and the cast-off skins of earlier instars. The scale coverings vary in different species. They may be circular, elliptical, or oyster shell-like, smooth or rough, and variously colored. The scale of the male is generally more elongated than that of the female. The male is not always present, and in this case virgin females reproduce asexually. Some of the species give birth to living young while others lay eggs. The armored scales do not secrete honeydew.

The following species may be found on greenhouse plants: (For critical identification of species, secure the help of the Extension Entomologist.)

The IVY SCALE (OLEANDER SCALE), *Aspidiotus nerii* Bouché: This scale may infest leaves and stems of a variety of greenhouse plants. The shield of the female is circular and whitish, with a nipple located more or less centrally. The male shield is elongated and similarly colored.



Ivy scale.

The FLORIDA RED SCALE, *Chrysomphalus aonidum* (Linnaeus): This species is also found on many plants, especially on palms and rubber plants. The roundish shield of the female is mahogany red with a central nipple. The male shield is oval and lighter in color.

The BOISDUVAL SCALE, *Diaspis boisduvalii* Signoret: This scale may attack a number of orchids and especially *Cattleya* and *Cymbidium* spp. The shield of the female is more or less circular, flat, thin and whitish, with a nipple nearly central. The males are usually clustered together in cottony masses. Their shields are white, elongated, with 3 ridges and a terminal nipple.

The CACTUS SCALE, *Diaspis echinocacti* (Bouché), closely resembles the Boisduval scale except that it mainly attacks cacti.

The ROSE SCALE, *Aulacaspis rosae* (Bouché), resembles the Boisduval scale also, but it has the nipple off-center and is mainly a pest of roses.

The FERN SCALE, *Pinnaspis aspidistrae* (Signoret): The shield of the female of this species is oyster shell-shaped and brown, with a terminal nipple. The male shield is more elongated and felted white. It is commonly found on many ferns, aspidistra, and on other foliage plants.

The GREEDY SCALE, *Hemiberlesia rapax* (Comstock): This scale may attack ivy, ficus, palm, fuchsia, and a number of other plants under greenhouse conditions. It resembles the ivy scale except that the female shield is quite convex with a prominent yellowish nipple off to one side.

The UNARMORED SCALES (soft, wax, and tortoise scales) belong to the family Coccidae. The female of this group may be flattened, oval or globular, with a usually smooth and rubbery outer covering which, in contrast to those of the armored scales, cannot be separated from the body of the female. A few species may secrete large amounts of wax. The eggs are laid in cottony egg sacs under the covering of the female or protruding from the covering. The female may continue to lay eggs for several months. Some species although stationary in habit may retain the legs and antennae in the adult stage. The male may be winged or wingless. These insects, in contrast to the armored scales, secrete a large amount of honeydew, which gives rise to the growth of the unsightly sooty mold on the host plants.

The following are the most important species attacking greenhouse plants:

The BROWN SOFT SCALE, *Coccus hesperidum* Linnaeus: The adult female is flattened, soft and pliable, shiny yellowish or brownish, with dark brown grid-like mottling. The species produces living young. It has a wide host range in greenhouses.

Soft brown scale: adult females.

The HEMISPHERICAL SCALE, *Saissetia coffeae* (Walker): The adult female has a strongly convex covering, hard and smooth, brown and shiny. The underside of the female is cupped to accomodate large numbers of eggs. It attacks many plants, ferns being one of the favorite hosts.

For control suggestions, see mealybugs.

Hemispherical scale: adult females.

SLUGS AND SNAILS

These animals are mollusks, not insects.

The snail is characterized by a hard external shell protecting its soft body. The slug, on the other hand, does not have an outer shell — its soft body is protected by a copious coating of slime.

Most active at night, these animals chew holes in leaves, stems, etc. The damage they produce is often confused with the injury caused by caterpillars. Caterpillars, however, leave a large amount of droppings on the plant's foliage, whereas slugs and snails leave only shiny patches or streaks of dried slime on plants and on soil. Also, slugs and snails chew completely through a leaf or stem, whereas caterpillars may leave part of the leaf veination, or a thin layer of leaf epidermis or part of the stem untouched.

Some of the snails and slugs found in greenhouses are not plant pests, but only an expert can distinguish them from pests.

In general, slugs and snails lay eggs. The offspring, although lighter in color and smaller in size, resemble the adult. The eggs are laid in moist locations in clusters of 20 to 100. Mulch, plant flats, boards, clay flower pots, etc., usually provide shelter and cool and moist conditions for egg laying. At temperatures above 50°F. eggs may hatch in less than 10 days; slugs may mature in 3 months to a year from hatching. The mature adult may live for a year or more. Slugs have both male and female organs on the same body, and may act as males and females at the same or different times of their adult lives. Self-fertilization is also possible.

Garden slugs.

Control of mollusks under greenhouse conditions may be achieved by means of molluscicides as well as by means of sanitation measures extended to outdoor areas surrounding the greenhouse. The following sanitation measures are suggested: careful inspection of all plant material prior to introduction into the greenhouse; elimination of weeds; improvement of water drainage; elimination of boards, flats, flower pots, etc., from under benches and other humid areas of the greenhouse; sterilization of soil, mulch, sand, gravel, etc., as well as equipment, prior to introduction into the greenhouse.

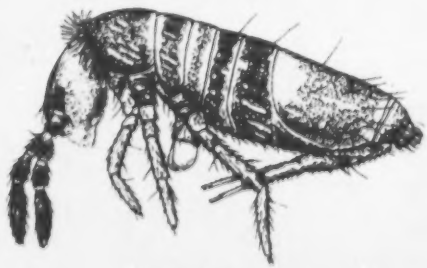
Snail.

These animals are usually introduced into the greenhouse with infested plant material and unsterilized soil, gravel, sand, etc., as well as with pots, flats and other equipment. Migration of slugs into greenhouses may also occur from surrounding areas, especially if they are weedy and full of rubbish.

At least 25 species of slugs and snails have been found in greenhouses. They are known mostly by their scientific, rather than their common, names. Different species may be identified as garden slugs or greenhouse slugs or orchid snails. The grower should always secure the services of an expert for proper species identification prior to the initiation of a major chemical control program.

SPRINGTAILS

These primitive wingless insects are often brilliantly colored and rarely more than 1/5 inch long. Their body segments are either fused into a globular mass (e.g. the garden springtail) or distinctly separate, giving the body an elongated shape (e.g. the snow flea). They may be found in soil, on trees, in water, on snow, etc. Antennae and simple eyes (8 on each side of the head) are present. Mouth parts are adapted for chewing or for sucking. A tube, called the "colliphore", is present ventrally on the first abdominal segment. The function of this tube is still unknown. The fourth or fifth abdominal segment is, in many species, equipped with a fork-like organ, the "furcula", with a spring-like action — hence the names springtails, snow fleas, etc.



Springtail: adult.

The soil inhabiting species usually lay eggs in batches. These hatch into pale colored young. As the young mature, they change only in color and size. [Springtails, in general, do not undergo a true metamorphosis.]

These insects are found in greenhouses mainly in damp soil rich in organic matter. They may be common at times in plant beds and in potting soil rich in humus. Many of the species are only scavengers, feeding mainly on decaying organic matter, while others feed on fungi and algae.

One species, however, is known to be particularly injurious to seedlings and to young and tender plant parts. This species, *Bourletiella hortensis* (Fitch), is commonly called the GARDEN SPRINGTAIL. It is globular in shape and dark purple to blackish, with numerous white spots. It may be introduced into the greenhouse with unsterilized soil and infested plant material, especially from hot beds and cold frames.

Sanitation and soil sterilization are most helpful in excluding this pest from the greenhouse.

Springtails in soil.

TARNISHED PLANT BUG

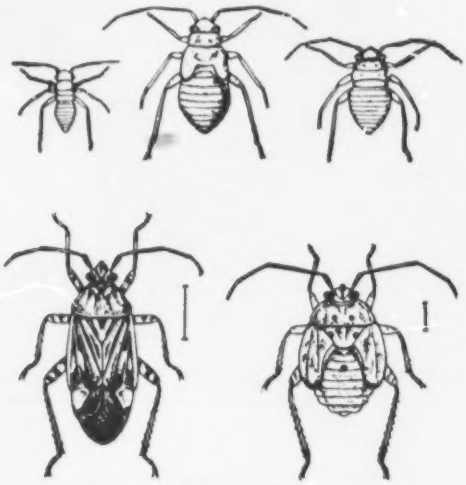
Lygus lineolaris (Palisot de Beauvois): This insect feeds on virtually all weeds, cultivated plants, and miscellaneous vegetation. It gains entrance to greenhouses through vents and any openings in the walls or ceiling which permit the passage of its 1/4 inch long, flat body. The tarnished plant bug is a serious pest of greenhouse grown composites, especially chrysanthemums, in Massachusetts.

The adult is winged and very active, taking to flight at the least disturbance. The bugs may occur in profusion, but remain unnoticed because of their protective coloration and shy, hiding habits. They are bronzish, marked with yellow and black dashes. The body is oblong, tapering towards the hind end. The head is small and triangular in shape, with prominent eyes.

The adult passes the winter under rubbish, weeds, fallen leaves, etc. The undergrowth and trash near greenhouses often gives excellent protection to the overwintering adults. The warmer greenhouse temperatures in early spring and late fall are most attractive to the insect. The adults and nymphs feed on plant sap by inserting their long beak-like sucking mouth parts into plant tissue, at the same time injecting poisonous saliva, which causes the death of the tissue. Typical plant damage includes death of tender terminal growth, "blind buds", and badly distorted buds which later wither and die.

The eggs are inserted into the epidermis of tender stems, petioles, midribs of leaves, etc., often causing minute swellings. Eggs are also tucked among petals of flowers. The egg is elongated and slightly curved, with one end cut off flush with the surface of the plant tissue in which it is imbedded. Hatching takes place in 7 to 10 days. The newly

hatched nymphs are 1/25 inch long, yellowish-green, and wingless, with long legs. They are often confused with aphids. They feed actively and undergo five molts. The last 2 nymphal instars have wing pads and resemble the adult more closely. The life cycle is completed in 3 to 4 weeks.



Tarnished plant bug: adult and nymphs.

The control of this pest is greatly facilitated by the removal of rubbish, weeds, and undergrowth from the area proximal to the walls of the greenhouse. The screening of vents, whenever possible, and proper tightness of greenhouse walls to ground level will interfere with its migration into the greenhouse from surrounding vegetation. A chemical barrier on the area immediately adjacent to the outer walls of the greenhouses will also contribute to the reduction of its migrations.

TERMITES

The eastern subterranean termite, *Reticulitermes flavipes* (Kollar), is commonly found in the Northeast. It may injure wooden structures in greenhouses as well as plants with thick and/or woody stems, such as geraniums, chrysanthemums, roses, etc. As this wood eating insect lives in darkness, no external signs of termite work are usually seen until irreparable damage to structures or plants becomes suddenly evident.

The colony of this termite is always partly in the moist ground. It is made up of workers, soldiers, brood and queen. The queen is usually found in the ground. The workers may carry on most of their activities in wood above ground but remain connected with the ground nest by means of burrows or of mud covered runways. [The latter are also called chimneys.] Once a year, winged forms of both sexes leave the nest to start new colonies. The swarming winged forms may also be seen during the daytime.

The broadly joined thorax and abdomen of wingless termites distinguishes them from ants, which have a narrow waist or petiole separating the two sections. In addition to the above characteristic, the winged termites have two pairs of opaque wings, equal in size but longer

a, termite;

b, ant.

than the body length. The winged ants, in contrast, have two pairs of wings which are unequal in size and shorter than their body length.

In areas where termites abound, all woodwork in greenhouses should be set in a concrete foundation well elevated above the ground. The foundation should be kept clean of soil and debris so that the termites will not be aided in constructing mud chimneys from the soil to the wooden structure and thus defeat the purpose of the concrete foundation. Infestation may also be prevented by elimination of discarded lumber from greenhouse premises at the time of construction and by general sanitation measures in greenhouses and adjacent areas, aimed particularly at preventing direct and prolonged contact of wooden items with the soil floor.

THRIPS

These tiny, slender, rod-like insects are at times important pests of ornamental plants under greenhouse conditions. The species most prevalent in the Northeast are minute in size, approximately 1/25 inch in length when fully grown. Due to their small size, hiding habits and ability to multiply rapidly, they usually do considerable damage to host plants before they are discovered. Some species are also carriers of "spotted wilt", a serious virus disease of many flowering plants. Thrips feed by means of their asymmetrical mouth parts (right mandible undeveloped) which are constructed to rasp and shred the tender surface of the plant tissues and to suck the juices that exude. The injured area of the plant turns white and this produces the silvering, blotching and streaking of the foliage and flowers typical of thrips injury. While feeding, thrips secrete reddish brown drops of excrement which turn black when dry. These dark dots are typical signs of thrips infestation. This damage should not be confused with that caused by spider mites, which will appear as extensive stippling of the host plant surface, with no signs of the blotching and streaking typical of thrips. In the absence of live stages of mites, a number of other signs will be found on the host plant such as a fine webbing, cast-off skins, empty egg shells, etc., which are typical of mite infestation.

The feeding thrips are usually found under bud scales, in open blossoms and in pollen sacs, down the axils of leaves, under bulb scales, etc. A quick way to detect the presence of thrips is to tap the suspect plant part on the palm of the hand, or on white paper or a clean white surface. The dislodged adults and wingless nymphs are made visible by this method.

The life cycle of thrips species found in greenhouses may be summarized as follows. The adult female inserts eggs in the host tissue by means of a saw-like ovipositor. The eggs hatch within a week. The hatching nymphs are wingless. They feed actively and molt twice. The 3rd and 4th stages preceding the adult stage have short wing pads, do not feed, and may be found on the host plant or in the soil. They are called [improperly] prepupa and pupa respectively. The entire life cycle will be completed in 2 to 4 weeks, depending on the greenhouse temperature.

The distribution of these tiny insects is aided by strong air currents, prevailing winds, etc. They may gain access to greenhouses through open vents and other openings, as well as on infested plant material.

The species most frequently found in greenhouses are listed below. The services of a trained entomologist should be secured for proper species identification.

ONION THRIPS, *Thrips tabaci* Lindeman: This species feeds on foliage and flowers of numerus ornamentals, edible crops and weeds. The adults are pale yellow to brownish in color. The larvae are creamy white to yellow. This species may readily enter greenhouses from surrounding weedy areas, onion fields, etc.

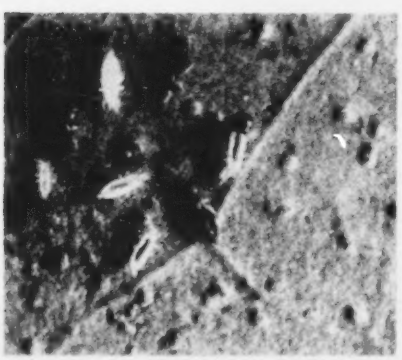
EASTER FLOWER THRIPS, *Frankliniella tritici* (Fitch): This is a migratory species. It is known to migrate northward from the Gulf States annually from spring to fall, but it is also introduced and distributed locally by means of infested plant material. The latter may be the most important means of introduction of this species into greenhouses in the Northeast. The characteristics separating this species from the onion thrips are visible mainly with the aid of a microscope. The two species share a broad host range. The flower thrips may complete a generation in two weeks.

GLADIOLUS THRIPS, *Taeniothrips simplex* (Morison): This is the most serious pest of gladiolus. It attacks all parts of the host plants, including the corms in storage. It is also found on flowers and foliage of related bulbous plants. The adult is dark brown to black, with wings having a characteristic light band at the base. The larva is yellow. The pupa is orange, with red eyes.

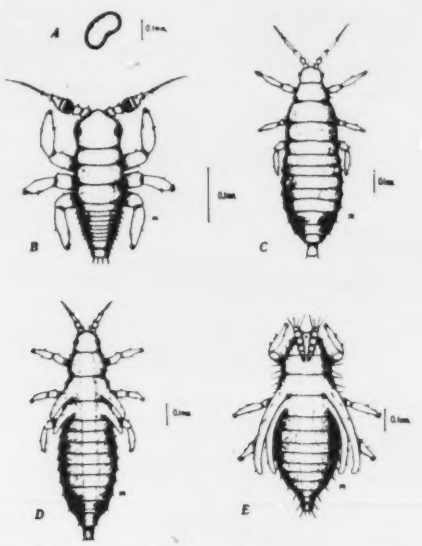
GREENHOUSE THRIPS, *Heliothrips haemorrhoidalis* (Bouché): This species may infest practically all greenhouse plants. The adult is dark brown with appendages and the tail end of the abdomen lighter in color. The body surface presents a characteristic network of lines. The larva is white and accumulates dark excrement on its back. The male of this species is unknown.

A satisfactory control of thrips in greenhouses and especially of species infesting flower parts is nearly impossible with pesticides presently registered for indoor use. The task is complicated by the sensitivity of flower parts to pesticide injury. Installation of fine mesh screen on vents and other openings has been suggested as a means of excluding the migratory and local species from greenhouses, but the success of this method is still questionable. Cultivation of host plants such as onions and gladioli, as well as of chrysanthemums and other composites, near greenhouses should be avoided. Good weed control on premises adjacent to greenhouses is helpful. Purchase of plant material from reputable sources, especially if in blossom or in the bulb stages, is highly recommended. Repeated and preventative fumigation or aerosol applications may be necessary to protect flowering crops. New systemics and contact insecticides are presently being evaluated against these pests.

Greenhouse thrips: adult female.



Greenhouse thrips: adults, nymphs, and oviposition blisters.



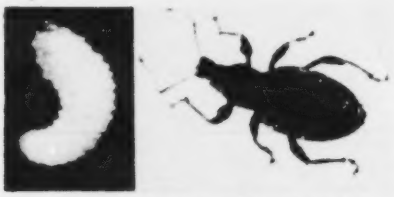
Developmental stages of thrips: a, egg; b, c, nymphs; d, prepupa; e, pupa.

WEEVILS OR SNOUT BEETLES

This group of insects contains a large number of species adapted to different habitats and therefore characterized by different habits. Some species exhibit a high degree of host specificity. The larvae of several species of agricultural importance feed on roots whereas the adults may feed on all aerial parts of plants. One of the most noticeable characteristics of these beetles is the prolongation of the anterior end of the head into a "snout" of variable length according to the species. The snout bears the mouth parts and two elbowed antennae at the anterior end. The body is hard, oval to cylindrical in shape. The ability to fly is reduced or lacking in some species. The larvae are grub-like, usually legless, C-shaped and more or less cylindrical. They have a well developed head and strong mouth parts. Pupation may occur in the soil, in pupation cells, or in cocoons where the larvae feed.

A number of weevils may be found at times in greenhouses but the BLACK VINE WEEVIL, *Brachyrhinus sulcatus* (Fabricius), is at present a major pest in Northeastern greenhouses.

The weevil is 3/8 inch in length, brownish black, with wing covers showing patches of yellow scales and coarse lengthwise punctured ridges. The top of the thorax is densely tuberculate. The weevil cannot fly; it feeds at night, causing scallop-like indentations in the hedges of leaves which are more unsightly than damaging. During the daytime it hides at the base of the host plants.



Black vine weevil: grub and adult.

Under outdoor conditions, the eggs are laid in the soil near host plants, ordinarily in July and August. They hatch in about two weeks into white legless grubs, C-shaped, with yellowish brown heads and are approximately 3/8 to 1/2 inch long. They actively feed on roots of the host plant and go through the winter as fully grown larvae. Pupation occurs in soil cells in early June. The male of this species is unknown to date and the unfertilized eggs produce only females.

The inability of the adult to fly does not handicap the spread of infestations locally because the weevils are able to crawl actively and enter greenhouses in this way. Infestations may also originate from infested nursery stock, especially from Yews (*Taxus spp.*) brought to or grown on the premises. Cyclamen is another host highly favored by the larvae. However, the host range includes more than 100 different kinds of plants such as azaleas, rhododendrons, gardenias, roses, strawberries, ferns, gloxinia, geraniums, palms, grasses, etc.

The control of the weevil may be facilitated by purchasing nursery stock certified to be free from weevil infestations, as well as by placing host plants to be used for landscaping away from greenhouse premises. Treatment of potential sources of infestations with pesticides should be initiated in May-June when the adults begin to emerge from the soil. Thus it is possible to eliminate them before they begin to lay eggs. The larvae are much more difficult to control than the adults and the older larvae more than the younger ones. Cyclamen and other herbaceous and woody host plants of the weevil destined for greenhouse forcing should never be placed among outdoor landscaping stock plants. All host plants of the weevil should be kept under strict surveillance once introduced in the greenhouse, for signs of unthriftiness, stunting, wilting and/or yellowing of aerial parts. Early detection of infestations will prevent costly losses. The root system and the surrounding soil ball of suspect plants should be inspected for presence of the C-shaped white grubs. Heavily infested plants should be eliminated and the others treated with soil drenches of an approved pesticide.

In areas where the weevil is of common occurrence the crawling weevil may migrate to greenhouses from surrounding outdoor areas usually in the fall. A pesticide barrier on the outer periphery of the greenhouse may interfere with the beetle migration.

WHITEFLIES

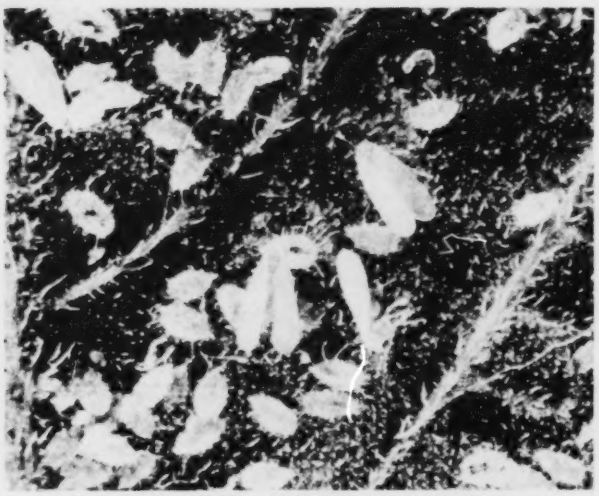
The most destructive species in the Northeast is the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood). This tropical insect has become established in greenhouses the world over. It is to our knowledge unable to survive the winters outdoors in the Northeast but in this area there is hardly a greenhouse entirely free of this pest during the entire year. The outdoor plants are usually infested by adults flying out of greenhouses through open vents as soon as the outdoor temperatures become favorable. The field planting of infested greenhouse material contributes to outdoor infestations. A reverse migration of whitefly adults from outdoors to greenhouses occurs in the fall of the year.

The adults and nymphs of this insect feed almost exclusively on the foliage of the host plants and mostly on the undersurface. They suck juices from the plants and secrete large quantities of sticky and glistening honeydew, which gives rise to the development of an unsightly black sooty mold. Severe infestations may also cause defoliation of the host plants. These abnormalities and the presence of large numbers of adults and nymphs usually render ornamental plants unsaleable.

The mature whitefly is a tiny four-winged insect, snow white in color and measuring approximately 1/16 inch in length. When flushed from heavily infested plants they alight like snowflakes.

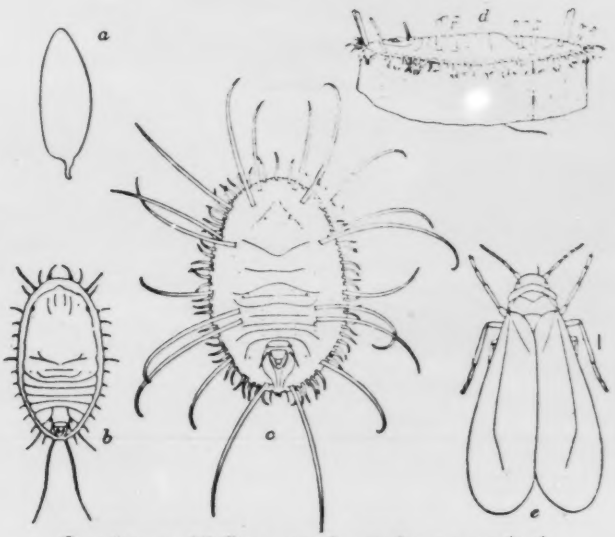
The life cycle may be completed under greenhouse conditions in 4 to 5 weeks. The female may live a month or more, laying up to 100 eggs. These are usually found on the young apical growth, while older developmental stages of the fly are found on the lower leaves. A large number of empty pupal skins are found on the oldest or senescent foliage and they are often mistaken for live flies or nymphs. As a general rule, the grower should assess the degree of control obtained with a given pesticide or assess the actual fly population in his greenhouse by inspecting the undersurface of the young foliage of the host plants.

The female lays her eggs in a circle. The number may range from a few to 20 or more. The eggs are spindle shaped, rising at one end from a short petiole. When newly laid, they are white, becoming grey, then black as they mature. They hatch in 5 to 10 days. The newly hatched crawlers are yellowish green, have legs and antennae, and crawl a short distance from the place of hatching. Upon settling, they insert their mouth parts into the plant tissue and begin to feed. After the first molt they lose their ability to move and become scale-like, flat, and transparent to greenish yellow in color. After 3 subsequent molts within a 3 week period, the larva transforms into the non-feeding pupa characterized by a plump, yellowish green body with conspicuous black eyes and with the perpendicular edges of the body wall often ornamented with waxy thread-like projections. The winged adult emerges a week or two later through a T-shaped split in the top of the pupal case. The cases remain, adhering to the leaf as white empty shells. The adult begins to lay eggs within 2 to 7 days of emergence.



Greenhouse whitefly: adults and empty pupal cases.

Lately, more effective chemicals (pyrethroids and juvenile hormone) have become available for the control of this pest under greenhouse conditions. Exclusion and prevention methods should continue to be applied, not only before utilizing an empty greenhouse, but also during the growing periods. The well known ability of this pest to develop resistance to pesticides, especially if they are frequently and indiscriminately used, should not be overlooked by the grower. A tiny wasp (*Encarsia spp.*) may be found parasitizing the larvae and pupae of the fly. The parasitized pupae of the whitefly become black and are therefore easily detected. The value of this wasp as an economical bio-control agent of the fly is at present under study in relation to its pesticide sensitivity, its temperature requirements for maximum efficacy as a parasite in commercial greenhouses, and the economical feasibility of its mass rearing for controlled release in greenhouses.



Greenhouse whitefly: a, egg; b, crawler; c. nymph; d, pupa, side view; e, adult.

PEST CONTROL METHODOLOGY UNDER GREENHOUSE CONDITIONS

EXCLUSION AND SANITATION

A careful management of the greenhouse environment is essential to an effective pest control program. The use of pesticides alone cannot guarantee a pest-free greenhouse. It is equally important to avoid introduction of mulches and other amending materials, equipment, soils and/or plant materials infested with pests, to buy plants only from a reputable firm which provides pest-free certification, and to inspect plant shipments carefully upon their arrival. Infestations on plants shipped from other states should be reported to the Director of Plant Pest Control, Dept. of Agriculture, 100 Cambridge Street, Boston, Tel.: 617-727-3031. Stricter regulations are needed in Massachusetts to prevent the commercial importation from other states of greenhouse ornamentals infested with insects and related pests.

Weedy areas around a greenhouse serve as actual or potential sources of diseases and insect pests. It is therefore important to practice weed control within the greenhouse and in the immediately surrounding areas. Weed seeds in beds and potting soil can be controlled by soil sterilization. (See Table 1, page 27)

Since trash, unused containers, boards and similar items provide protection for night feeding pests, they should be eliminated. Areas under benches should be kept free of plants, weeds, and equipment and proper water drainage assured. Greenhouses should be thoroughly cleaned after each crop, all plant parts and debris eliminated, and soil, tools, and benches sterilized. The greenhouse should be given a cleanout fumigation before a new crop is introduced. The soil mass, freed of plant parts, including roots and debris, must be steam sterilized or

chemically fumigated. Steam sterilization is the preferred method.

The ground soil should not be allowed to dry out between fumigations or steam sterilizations because lack of moisture causes the migration of insects and other pests to deep, humid layers beyond the reach of fumigants and heat.

Aerosols, smokes, etc., used for cleanup purposes between crops may be applied at concentrations higher than those suggested when plant material is present, provided that all safety precautions given on labels are heeded. Structural leakage must be taken into account when selecting pesticides and determining concentrations and duration of fumigations in empty greenhouses. Calcium cyanide (granules or flakes) may still be used for general clean-up. Label instructions for using this highly toxic pesticide must be followed faithfully and exactly.

Screening of ventilators and doors with wire screens (14 meshes/inch) will exclude a number of serious pests from the greenhouse. Structural tightness of greenhouse walls down to soil level (which is preferably kept barren) will help to exclude crawling pests.

HOT WATER STERILIZATION OF BULBS, CORMS, AND OTHER STORAGE ROOTS

This method may help in controlling mites, maggots, aphids, and thrips. The bulbs, corms, etc., are submerged in water at a temperature ranging from 110°-111°F for 2½ to 3 hours. Temperatures above 111.5° may injure plant material. Control of cyclamen mites requires immersion for only 20-30 minutes. The water should be agitated during immersion to assure uniformity of temperature within the body of water.

MATERIALS AND METHODS FOR PRE-PLANT SOIL TREATMENT AND STERILIZATION* *

CHEMICAL FUMES ARE TOXIC TO PLANTS AND GREENHOUSE MUST BE EMPTY

TABLE 1

Chemicals	Some Trade Names	Effective Against	Methods of Application	Delay Before Use
Steam	—————	Fungi, bacteria, nematodes, soil insects, and weeds	Raise temperature of entire soil mass to 180°F. Maintain for ½ hour. Check with reliable thermometer. Have soil tested before and after sterilizing.	Cool and have soil tested before using to check for pH problems and changes in soluble salt levels.
carbamate	Vapam, VPM	Most fungi, nematodes	Drench or injection seal with water. Works best between 50° and 90°F.	2-3 weeks, 3-4 weeks if wet and cold.
dichlorophenyl, diethyl phosphorothioate	VC-13	Nematodes	Drench, no cover or seal required. Works best between 50°F and 90°F.	2 weeks pre-plant.
dichloropropane dichloropropane mixture plus methyl isothiocyanate	Vorlex	Most Fungi, nematodes and weed seeds	Injection, no cover or seal required. Works best between 50°F and 90°F.	2-4 weeks
methyl bromide plus chloropicrin* under pressure	MC-2, Pestmaster Soil fumigant-1	Most fungi, bacteria, nematodes, soil insects, and weed seeds, depending on rates used.	Injection, tight cover or seal for 24 hours. Works best between 50°F and 90°F.	3-7 days. Must be well aerated.

* Bromine-containing fumigants are not recommended for treating soils that will be planted with carnations or salvia.

THESE MATERIALS ARE LISTED FOR SELECTION PURPOSES ONLY. FOR SPECIFIC RATES AND METHODS AND PROCEDURES OF APPLICATION, READ THE LABEL AND CAREFULLY FOLLOW MANUFACTURER'S DIRECTIONS.

THESE MATERIALS ARE SUGGESTED FOR USE ONLY UNDER GREENHOUSE CONDITIONS.

* * From Florogram, 1976, William J. Manning, "Disease Control For Floricultural Plants for Commercial Growers Only."

DISINFECTANTS FOR POTS, BENCHES, AND EQUIPMENT **

TABLE 2

Materials	Effective Against	Methods of Application
steam	Fungi, bacteria, nematodes, soil insects and weed seeds	Cover flats, clay pots, and benches. Steam at 180°F for ½ hour.
Household bleach containing 5.25% sodium hypochlorite by weight. e.g. Clorox*	Fungi and bacteria	Use 10% solution — 1 part bleach for 9 parts water. Drench empty benches, tables, flats, tools, etc. Soak clean pots for 30 minutes and use directly. A new solution should be made up for each lot of pots treated. Automatic watering system tubing should be flushed with water before re-use.
LF-10*	Fungi and bacteria (except resistant survival structures of some fungi)	1 part LF-10 in 200 parts water (e.g. 1 pint in 25 gal water). Drench empty benches, flats, other surfaces, tools, etc. Use 1 part LF-10 in 100 parts water (e.g. 2 pints in 25 gal water) to soak pots and automatic watering system tubing for 1 hour. Pots and tubing should be flushed with water before use.

* Trade Names

DISINFECTANTS ARE FOR SUPPLEMENTAL USE ONLY. THEY ARE NOT ADEQUATE SUBSTITUTES FOR A THOROUGH SOIL STERILIZATION-SANITATION PROGRAM.

THESE MATERIALS ARE SUGGESTED FOR USE ONLY UNDER GREENHOUSE CONDITIONS.

NOTES: 1. RUBBER GLOVES AND PROTECTIVE CLOTHING SHOULD BE USED WITH CLOROX* AND LF-10* SOLUTIONS.

2. THE USE OF LF-10 AND CLOROX TREATMENTS WITH CLAY POTS MAY LEAD TO PLANT INJURY PROBLEMS.

** From Florogram, 1976, William J. Manning, "Disease Control for Floricultural Plants for Commercial Growers Only."

BIOLOGICAL PEST CONTROL

Biological Pest Control is defined as the control of pests by means of their natural enemies, e.g. parasites, predators and disease-producing agents. Examples of biological pest control presently under study would be the release in the greenhouse of the parasitic wasp *Encarsia formosa* (Gahn), for the control of whiteflies, or the release of predaceous mites, *Phytoseiulus* spp., which feed on plant-infesting mites. Spray applications of spores of *Bacillus thuringiensis* (Thuricide,* Dipel,* Biotrol,*) have already proven successful for the control of loopers, leaf rollers, leaf tiers and cabbage worms in greenhouses. The integrated utilization in pest control of natural enemies, cultural practices and of selective pesticides (effective against specific pests) is called Pest Management.

CHEMICAL PEST CONTROL

The following guidelines should be adhered to when chemical pest control is the method of choice.

1. Disinfest suspect plant material before its introduction into the greenhouse, preferably in a quarantine area or house assigned to this activity.

2. Know the pest to be controlled. If you cannot identify the pest and/or are not familiar with its biology and habits, seek the help of your county agent or the extension entomologist. Do Not Guess. A pest incorrectly identified could mean the wrong control, which in turn means time and money lost.

3. Select the proper chemical and the correct formulation (liquid, granular, wettable powder, aerosol, etc.) for controlling the pest. Ascertain that the selected pesticide bears on its label the EPA Registration Number as well as the name of the insect (e.g. cabbage loopers) and the plant for which it has been selected (e.g. chrysanthemums) and the location (e.g. greenhouse) for its use. Ascertain whether the pesticide has been registered for intrastate use in greenhouses. Use the pesticide in the amount per acre or per 100 gal. of spray indicated on the label. Do not overlook the stage of development of the plant and its possible sensitivity to chemical damage. (See the sections on pesticide applications and compatability and the list of plants sensitive to particular pesticides.) Consult competent and unbiased authorities in the field of pest control for up-to-date recommendations. If your county agent

* Trade Names.

cannot help you he will know where to get the proper advice.

4. Use pesticides safely — READ THE LABEL ENTIRELY! Do not rely on your memory. To prevent and avoid accidents, use proper equipment and exercise caution, following label instructions to the letter. Observe strictly any label limitations as to time intervals between the application of the pesticide and the marketing of the crop. *Place warning notices on all entrances to premises under treatment.* Notices should feature the word "Danger" or "Warning" in large print and state that a pesticide is in use. The telephone number together with the name of the person responsible for the control operation should also appear on the warning notice. Do not enter treated premises unless it is safe to do so according to label instructions. Instruct all personnel on the proper use of pesticides and on the proper handling of emergencies. Post up-to-date emergency poison treatment guidelines** and the list of Poison Control Centers on the premises. Provide bilingual guidelines if necessary. See sections on Safe Storage and Disposal of Pesticides and become familiar with the table of "Toxicity of Insecticides" included in this manual. Do not allow unqualified personnel to use restricted and/or highly toxic pesticides.

5. Keep accurate records. Records of chemical pest control activities are required by the State and Federal Environmental Protection Agencies. Your records should include date of application, pest and crop involved, the material used, its formulation and the amount used. (See example chart below.) It is to your own advantage to also include the weather conditions, the name of the applicator, the severity of infestation and other information which may be helpful in determining the efficacy of the control as well as protecting your interests in case of legal inconveniences.

PEST CONTROL RECORD

CROP _____ HOUSE _____ BENCH _____

DATE	MATERIAL	FORMULATION	AMOUNT USED	PEST	APPLICATOR'S INITIALS

PESTICIDE FORMULATIONS AND METHODS OF APPLICATION

DUST AND SPRAYS

A pesticide dust is a finely ground, dry mixture composed of an active pesticide and an inert carrier such as clay, talc, diatomaceous earth, etc. Since it is difficult to avoid inhaling dust particles under greenhouse conditions, spray formulations are recommended rather than dusts, inasmuch as they are less hazardous to the operator and consumer. Hydraulic spraying is a standard method of applying pesticides in the greenhouse. When a hydraulic sprayer is used, the nozzles must be clean and pressure must be maintained at a constant level to achieve an even, uniform coverage of all plant parts. Coverage is critical for proper pest control; both lower and upper surfaces of foliage must be thoroughly sprayed up to the run-off point.

The choice of a pesticide formulation for hydraulic spraying, whether a stomach or contact poison or a systemic, is a matter of personal preference. However, several factors should be kept in mind:

Wettable powders (WP) are solid particles which wet and disperse in water with the aid of surface active agents (surfactants). They are less likely to be phytotoxic to plants than emulsifiable concentrates (EC); however, they leave a visible white residue on plants which may be considered objectionable. Also, wettable powders require continuous agitation in the spray tank to prevent them from settling out and are known to cause considerable wear on nozzles and pumps. Often, it is necessary to add a wetting agent and/or a sticker to wettable powder formulations (unless otherwise indicated on the label) to insure proper coverage of plant parts. Trial and error may be necessary to determine the need for a surfactant. If the spray rolls off the plant surface or remains on the leaves in droplets, instead of as a uniform film, a surfactant may be added at rates suggested by the manufacturer.

Emulsifiable concentrates (EC) are oily solutions of pesticides in an emulsifying agent. This agent, when added to water, breaks into very fine droplets. With the evaporation of the water and other carriers, EC provide the longest lasting residual deposits. They are also more resistant to washing off. Because they are more likely to be phytotoxic, it is wise to test an EC formulation on a few plants in blossom and/or foliar stages for possible damage. Tank mixes of EC with EC or of EC with WP formulations may be even more phytotoxic. Spray applications during warm summer days in direct sunlight may cause scalding of plant parts. Spray applications under humid conditions and poor ventilation are also conducive to plant injury and favor fungal infections.

** "Emergency Medical Treatment for Acute Pesticide Poisoning", from the U.S. Navy Disease Vector Control Center, U.S. Navy Air Station, Jacksonville, Florida, 32212.

Some spray formulations (usually EC) may be applied with mist blowers. Unlike hydraulic sprayers, mist blowers utilize a high-volume, high-velocity air stream to deliver low volumes of highly concentrated pesticides broken into mist-like particles. The mist blower operation requires greater skill than that of the hydraulic sprayer. The operator must take into account several important factors: the highly concentrated spray formulation in the tank, the flow rate at the nozzle, and the correct duration of the misting to attain uniformity of coverage without injuring the plant material and without deviating from label recommendations.

AEROSOLS

Aerosols are obtained by releasing a solution of pesticide in propellant gas, usually a low boiling hydrocarbon with small amounts of a petroleum derivative solvent, from a pressurized container. Flammability is the undesirable characteristic of these preparations. Several aerosols are available commercially, or they may be prepared by the operator. The dispenser may be a pressurized cylinder or a mist-producing mechanical generator; in the latter case, the pesticide particles will be larger in size. To obtain good results with most aerosols, the temperature of the greenhouse and of the contents of the dispenser should be between 80-85°F. Higher temperatures may cause plant injury and may result in the bursting of dispensers. Lower temperatures result in the improper delivery and distribution of the aerosol and poor kill of the pests. Applications at sunset or on cloudy days are preferable. Read the label for exceptions to the above temperature requirements. Prior to aerosol treatment, all flames, including pilot lights, should be extinguished and all fans turned off. The aerosol should be distributed as evenly as possible throughout the greenhouse. Foliage should be dry during applications but plants should be well watered. Blossoms of many plants are sensitive to aerosols. Ventilators, doors, etc., should be closed before application and kept closed for the length of time indicated on the label, or for not less than 3 hours. If the greenhouse temperature goes above 85°F, the ventilators should be opened at once and fans turned on. Protective equipment should be worn according to label instructions when applying an aerosol or entering the area under treatment. Warning signs should be posted on all entrances. (See Common Sense Rules and Safety Equipment discussed in this manual.) Application dosages may require a 5-10 second delivery from dispensers per 100 cubic feet or per 100 square feet of surface area. The lower dosage is usually applied in tightly constructed greenhouses and when plants are small in size. Instructions on the pesticide label and those provided with the aerosol dispenser should be followed carefully.

FOGS

Fogs are produced by vaporizing oil-base formulations of insecticides on heated pipes (this method may cause corrosion of pipes) or skillets. In commercially available fog generators, the formulations are injected into a heated pipe or exhaust or into a heated air stream. The insecticide formulations are generally marketed by the manufacturer of the fog generator with instructions for proper use. For ambient temperature and plant conditions at the time of applications and for safety precautions, see the discussion of Aerosols. When in operation, the foggers, (depending on the model and width of the greenhouse) are either carried or pulled through one or more walks of the greenhouse. If the greenhouse is small, it may be feasible to make the application from a fixed location. The fog discharge should not be directed toward the plants because the settling of larger droplets and hot exhaust scales may cause burning of the foliage and flowers. Fogs per se may cause injury to flowers of many plant species. The fog should be aimed under the benches or toward the ground. Fogging equipment should be cleaned frequently to prevent carbon incrustations in the fogging outlet.

Before buying a fogger, it is wise to make a comparison of the different models available, to see the fogger in operation on the premises, and, whenever possible, to obtain the fogger on loan for personal evaluation. A fogger should be suited to the size of the operation, require simple maintenance and calibration, and, preferably, be suitable for delivery of formulations other than those marketed by the manufacturer.

SMOKES

Smokes are generated by igniting combustible formulations which contain the insecticides. Smokes have less residual pesticidal toxicity than aerosols, fogs, and mists, and are somewhat safer on plants and blossoms as well. Plants must be kept well watered and the foliage dry when smokes are used. Air temperature should be within the 70-85°F range, unless otherwise indicated on the label.

To calculate the number of smoke generators needed, first determine the cubic feet of greenhouse area (see page 34-35.) Divide this figure by the number of cubic feet that a single generator will treat. The resulting figure will indicate the number of generators necessary to give proper control. Drafts and air leaks should be eliminated or reduced to a minimum when using smokes. All vents must be closed and fans stopped. Avoid applications during windy days. After the smoke generators have been ignited, place a warning sign on all doors stating that pesticides are in use. Heed common sense rules for the use of pesticides (See page 32) and the label's instruction.

SOIL APPLICATIONS

Systemic insecticides are often applied to the soil as drenches or as granular formulations for the control of sucking insects such as aphids, thrips, mites, etc. These chemicals are taken up by the roots of young and vigorous plants and translocated to nearly all the plant organs on which the sucking pests feed. *Nearly all the systemic pesticides presently available are highly toxic to mammals.* They should not be applied to greenhouse soil that will be used for the production of edible plants. To avoid injury to personnel and phytotoxicity to sensitive plants, the label must be followed carefully, the correct concentrations applied, and all safety instructions heeded. *Beware of mechanical dispensers of questionable accuracy.* Calibrate equipment for dispensing liquid formulations or granules accurately. (See "Temik" section on page 40.) Do not apply granules or drenches to ground beds before steam sterilization. Do not apply any pesticide to soil beds, potting soil, soil amending materials, or equipment that will be handled by personnel. Do not mix pesticides with fertilizers and herbicides. Excessive use of pesticides may lead to accumulations in the soil detrimental to plant growth and hazardous to personnel. All of the above precautions should also be observed when non-systemic chemicals are used for the control of soil insects.

TIMING OF PESTICIDE APPLICATIONS

To determine the pesticide application schedule, the following questions must first be answered:

1. What is the pest to be controlled; what are its habits, and the speed of its development (time required to complete its life cycle)?
2. What is the stage of development of the plants to be treated (foliar, bud, blossom)? What is the sensitivity of each stage to pesticides?
3. What is the effectiveness of the selected pesticide against the stages of development of the pest present (eggs, young, adults)?
4. What is the residual toxicity of the pesticide which will be used in relation to the rate of reinfestation of the greenhouse, speed of development of the pest, the handling of plants or soil by personnel, and the marketing date of the crop?

Once the above questions are answered, it is possible to decide the frequency of application necessary for a given pesticide application. For example, if, to control aphids, which may complete a generation in two weeks as well as reinfest the greenhouse continuously, you use an insecticide with a residual activity of 4 to 7 days and a maximum control rate of 80%, it will be necessary to treat a high cash crop repeatedly and up to bud stage if the chemical injures blossoms.

COMPATIBILITY OF PESTICIDES

If it is planned to mix two or more pesticides for a single tank application, the pesticides involved must be compatible. If they are not, there could be phytotoxic reactions and/or the efficacy of the control could be diminished. As a general rule, unless specific label instructions provide for such use, only tank combinations recommended by Agricultural Experiment Stations, State Departments of Agriculture, or those combinations already established and officially endorsed locally as a common agricultural practice should be used.

When combination mixes are made, the guidelines below are suggested:

— Read the label for compatibility statements.

— To the extent possible, do not physically mix unlike formulations in the same tank; for example, avoid mixing an emulsifiable concentrate with a wettable powder formulation.

— Do not mix pesticides with oils until compatibility has been determined.

— Do not mix pesticides with herbicides.

— Do not mix alkaline solutions such as those containing some fertilizers with pesticides.

— Apply a tank mix to a few trial plants and allow a week's time to assure that the mixture is not phytotoxic.

PHYTOTOXICITY [INJURY TO PLANTS] OF PESTICIDES

If all label instructions are followed, and the fresh and properly stored pesticide is applied only to the crops for which it is registered, at the correct concentration with properly calibrated equipment, phytotoxicity should not be a problem. Blossoms are sensitive to most pesticides. (See the list of plants sensitive to pesticides and acaricides given on page 45 in this manual.)

CARE OF EQUIPMENT

The dependability and safety of all equipment rest on its proper maintenance. After use, all equipment, including hoses, should be flushed out with water, drained, and stored in a protected area. If the equipment must be stored in areas where the temperature will go below freezing, it must be drained thoroughly. It would be even better to circulate antifreeze (alcohol base) through such equipment. All nozzles should be removed, cleaned, and stored; they should, of course, be replaced when wear becomes evident. Wettable powder formulations cause more wear of nozzles and of components of pumps.

SAFETY PRECAUTIONS

The majority of poisonings involving applicators are caused by pesticides coming in contact with the skin (dermal poisoning) or inhaled as aerosols, mists, fogs, etc. Many pesticides are absorbed rapidly through skin, especially in their concentrated formulations. If a pesticide is spilled on your skin, *don't delay — wash it off immediately with plenty of soap and water,* since it can be absorbed within a minute or two. Don't take unnecessary risks. Avoid potential hazards by wearing the proper protective equipment. Read the pesticide label — it will give instructions on the proper safety equipment to wear. Some safety equipment is reviewed below.

GLOVES

They should be made of rubber, unlined, and elbow-length. Keep several clean pairs on hand. They should always be worn when handling organo-phosphates, carbamates, or other chemicals with "Poison" or "Warning" labels. Elbow-length gloves offer protection to the wrists. To prevent pesticides from running down into the gloves, keep sleeves outside the gloves with the aid of rubber bands. Gloves should be replaced immediately if cracks or holes appear. Cotton or leather gloves should not be used because they tend to absorb and hold the pesticides close to the skin. Gloves should be washed with a detergent *before removing* to avoid contaminating the hands.

COVERALLS

Clean, dry coveralls capable of covering the entire body from neck to wrists and ankles should be worn when applying toxic chemicals. Several clean pairs should be on hand and stored in a non-contaminated area. Waterproof coveralls should be worn where there will be exposure to mists, fogs, or sprays that would wet through cloth coveralls. After each use, overalls and all clothing worn in the process should be washed with a detergent separately from other laundry. If clothing and/or overalls have been exposed to a spill of a concentrated pesticide, destroy them at once. Studies indicate that even after repeated and thorough washings, cotton cloth contaminated with highly toxic pesticides may still retain toxic levels of these materials.

BOOTS

Boots, like gloves, should be made of unlined rubber. They should be worn *inside the trouser legs*. Keep several clean pairs on hand. Pesticide residue should be removed by washing and drying the boots after each use.

HEAD AND NECK COVERINGS

It is important to protect the head and neck when applying pesticides. It is as easy to be poisoned dermally on the neck, face and head as on the hands and arms. Coveralls should be kept fastened at the neck. A hood or a hat with a wide brim, made of water repelling rubber or plastic, should be worn. Cotton or felt should be avoided because they absorb pesticides. The hat or hood should be washed after each use.

GOGGLES OR FACE SHIELD

Tight-fitting, non-fogging goggles or a full face shield are necessary if there is any possibility of pesticide contact with the eyes (from dusts, aerosols, mists, fogs, smoke, vapors, etc.). They must also be worn during work with toxic sprays or dust as well as when concentrates are being mixed or poured. Head bands of goggles should not be made of material capable of absorbing pesticides. They should be worn under the head covering, if possible. Extra head bands should be available for replacement. Proper maintenance of face equipment is essential to safety.

RESPIRATORS

Respirators guard against the inhalation of toxic fumes and other airborn particles of pesticides. They should be worn as a precaution whenever there will be exposure to pesticides, no matter what the duration of the exposure. The pesticide label will indicate whether a respirator is required and the type to use. As with goggles, a respirator should always be worn when pesticides are being mixed or poured.

Cartridge respirators usually cover only the nose and mouth and are recommended for protection against pesticides having the signal word "Caution" on the label. This type of respirator has one or two cartridges covered with a felt-like outer disk. These filter out the toxic components of the fumes, vapors, mists, fogs, dusts, sprays, etc. When a cartridge respirator is used, goggles should be worn. The felt disk should be changed as soon as it becomes dirty or breathing becomes difficult. The cartridges should be changed after 8 hours of use and as soon as pesticide odors are detected, when the mask is tightly worn on the face.

Gas mask respirators, in contrast to cartridge respirators, cover the entire face, protecting the eyes as well. They have canisters with a greater capacity for absorbing toxic fumes than do the cartridge respirators, and may also be connected with an oxygen supply. If an applicator is to be exposed to pesticides with the signal words "Danger — Poison" or "Warning" on their labels, he should use a gas mask respirator.

When respirators are used, it is important to adhere to the following rules:

1. The respirator should fit properly, but should not be so tight as to cause discomfort.
2. Cartridges and canisters should be changed as necessary, i.e. if breathing is difficult, if a pesticide odor is noticeable, or after 8 hours of use, or as suggested by the manufacturer.
3. After each use, the face piece should be washed with a detergent and warm water.
4. The respirator should be stored, along with filters and cartridges, in a clean, dry spot away from pesticides.

All respirators must be marked with a registration number, indicating approval by the Bureau of Mines and the National Institute for Occupational Safety and Health (NIOSH). Be aware of new safety rules concerning more efficient types of respirators. Respirators and accessories may be purchased from the following companies:

Acme Protection Equipment Co., 1201 Kalamazoo St., South Haven, Michigan 49090

American Optical Co., Safety Division, 100 Cannal St., Putnam, Connecticut

Davis Emergency Equipment Co., 45-47 Hallect St., Newark, New Jersey 07104

Mine Safety Appliances Co., 201 North Braddock Ave., Pittsburgh, Pennsylvania 15208

Pulmosan Safety Equipment Corp., 30-48 Linden Place, Flushing, New York 11354

Rite Hardware Manufacturing Co., 540 West Chevy Chase Drive, Glendale, California 91209

Welsh Manufacturing Co., 9 Magnolia St., P. O. Box 800, Providence, Rhode Island 02909

Willson Products Division, The Electric Storage Battery Co., Box 622, Reading, Pennsylvania 19603

COMMON SENSE SAFETY RULES

—Read the entire label *before* purchasing or using a pesticide and be prepared to follow directions exactly. Is the product registered for use in greenhouses against the pest you want to control and on the plant you wish to protect? Can you use the product safely in your place of business? Are you properly qualified for the use of the selected type of pesticide?

— Extinguish all flames, including pilot lights, when using fumigants or if you are so instructed by the label. Place warning signs and emergency information on all entrances.

— Work in pairs when handling toxic materials. Watch your partner for unusual behavior while staying outside the greenhouse and fully equipped for prompt rescue.

— Never smoke, eat or chew while applying pesticides.

— Avoid inhaling any volatile part of the pesticide formulations.

— Always wear clean protective clothing and the proper mask, not only when the applications are made, but also when *re-entering* the greenhouse to ventilate after applications.

— Do not handle or market newly treated plants — adhere to the waiting period indicated on the pesticide label or seek proper advice.

— When liquid concentrates are accidentally spilled on the skin or clothing, remove contaminated clothing immediately and wash the contaminated skin thoroughly with plenty of soap and water. Have your cholinesterase level checked immediately if the chemical is a cholinesterase inhibitor. (carbamates and organo-phosphates)

— Wash all clothing used during pesticide applications separately from other laundry. Destroy badly contaminated clothing.

— Wash the entire body thoroughly after pesticide applications — including fingernails and hair.

STORAGE OF PESTICIDES

Storage of pesticides without proper safety precautions may lead to serious, if not fatal, accidents. The following suggestions may prove helpful in securing proper and safer storage of pesticides:

— Mark the storage area clearly with a prominent water-repellant sign, "Poison Storage — Keep Out." This sign should be readable at a distance of 20 feet. All sides of the building should be marked.

— Keep the storage area *locked* at all times and at temperatures above 40°F and below 90°F.

— Provide the police, fire department and public health officials in writing with the location and layout of the storage area or building. They should also be informed about the materials stored, related hazards, and who is responsible for the storage.

— Post on the premises a list of "Poison Control Centers" with addresses and phone numbers. A copy of "Emergency Medical Treatment for Acute Pesticide Poisoning" (see page) should be posted. Gas masks, rubber boots, gloves, overalls, hats, shovels, and brooms as well as hoses, a water outlet and soap should be within reach at all times.

— Post a list of chemicals stored and their arrangement on the outside of the storage area.

— Be sure fire fighting equipment for extinguishing chemical fires is available. Know how to operate it correctly.

— Pesticide containers should never be placed in front of windows. Glass containers, especially, should be kept out of the sunlight. Exposure to light and heat may cause explosions and ignition, or chemical breakdown of the product.

— Keep combustible material away from steam pipes and heat. Note flammability precautions on labels and store accordingly.

— Highly toxic pesticides should be grouped in a single area. Store herbicides separately from all other pesticides.

— Keep all pesticides in their original containers. Dispose, at once, of all torn and/or leaking containers, of old and banned products, and of those containers which have lost their labels. Assume all unlabeled pesticides to be highly toxic.

— Keep hydrated lime and household bleach on hand to neutralize pesticide spills. Absorbent materials such as cat litter, activated charcoal, vermiculite or saw dust should be stored on the premises to soak up spills.

— The floor of the storage area should be paved with non-absorbent material. The area should be securely locked and kept clean, cool, dry, well ventilated and provided with electric illumination.

Remember — orderliness is important; a sloppy storage area is conducive to carelessness.

SHELF LIFE OF PESTICIDES

Although pesticides may have a storage life under optimum conditions of more than one year, it is advisable not to buy more than will be utilized in one or two growing seasons. The absence of the expiration date and/or date of packaging from the label further justifies this approach.

Exposure of liquid, dust, wettable powder and granular formulations to humidity, air and light and to temperatures below 40°F and above 90°F may cause detoxification of the chemical preparations.

Make an inventory of all pesticides available in storage and MARK CONTAINERS WITH DATE OF PURCHASE. Dispose of pesticides showing the following signs of deterioration:

FORMULATION	GENERAL SIGNS OF DETERIORATION
Emulsifiable concentrates	When milky coloration does not occur with the addition of water and when sludge is present or any separation of components is evident in the container.
Oil Sprays	When milky coloration does not occur with the addition of water.
Wettable Powders	When lumping occurs and the powder will not suspend in water.
Dusts	Excessive lumping.
Granulars	Excessive lumping.
Aerosols	Generally effective until the opening of the aerosol dispenser becomes obstructed.

PESTICIDE DISPOSAL

Proper disposal of pesticides is as critical as any other phase of pest control. A pesticide disposed of improperly can be hazardous to man as well as detrimental to the environment. A liquid pesticide container should be rinsed three times when it is emptied, allowing the container to drain well between each rinse (approximately 30 seconds). If it is practical, the rinse material should be poured into the spray tank. Before disposing of containers which held powders or granular pesticides, special care should be

taken to remove all materials from the containers. Never leave equipment and material that may be hazardous to man and environment unattended.

AN "EMPTY" PESTICIDE CONTAINER SHOULD NEVER BE USED FOR ANY OTHER PURPOSE. The smallest trace of a pesticide is potentially dangerous. If containers cannot be disposed of immediately, they should be stored in a safe, preferably locked, area. For current state regulations regarding pesticide and container disposal, the State Regulatory Agency's Chemical Leader or the Extension Service should be contacted.

Advance planning is advisable when formulating pesticides for pest control applications. Only the amount needed to do the job should be made up and equipment should be cleaned immediately after each use. Equipment should be cleaned in an area where rinse water will not collect or contaminate adjacent areas and ground water. The area should not be accessible to children, unauthorized personnel, and animals.

CHOLINESTERASE TESTS

Cholinesterase is an enzyme necessary for the proper function of the nervous system in man. Carbamates (Sevin, Temik, Zectran, etc.) and organo-phosphates (Parathion, Malathion, Diazinon, Systox, etc.) are cholinesterase inhibitors. Repeated exposure to these types of pesticides may, without warning, cause prolonged sensitivity of the applicator to gradually smaller doses of *any* cholinesterase inhibitor.

We strongly urge all pesticide applicators, as well as those people working in areas and on premises where pesticides are used, to have their cholinesterase level routinely checked by a physician through periodic blood tests. It is important that the cholinesterase level of each individual be determined *prior to major seasonal activities*. This will provide the doctor with a record of the patient's normal cholinesterase level. There are two types of cholinesterase tests — a red cell or *true* cholinesterase test, and a plasma or *pseudo* cholinesterase test. The true test is preferable. Cholinesterase tests may be secured through local doctors, hospitals, or private laboratories.

PESTICIDE DELIVERY CALCULATIONS

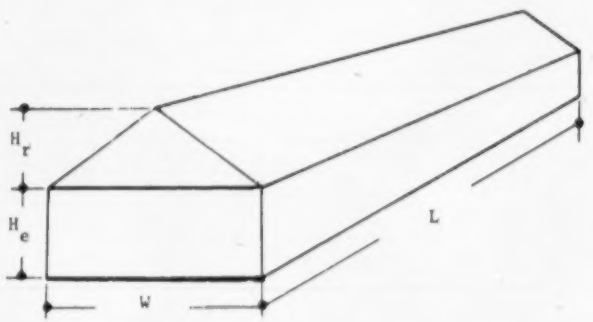
It is essential that the recommended dosage of a pesticide be applied in all pest control treatments. If the dosage applied is insufficient, materials are wasted, time is lost, and, most importantly, the desired control is not attained. This may lead to additional pesticide applications that will accelerate the build-up of pests resistant to the chemical and increase the hazards to man and the environment. Dosages which are larger than recommended can be equally wasteful and injurious. To insure that the correct dosage is applied, the following information must be available:

1. Labeled dosage rates.
2. The size of the area to be treated: greenhouse volume in cubic feet for fumigations (smoke, fog, mist, etc.) or square feet of planted area and type and height of plant material for sprays, dusts, aerosols, and soil applicatioin.
3. The capacity in pounds or gallons, etc., of the equipment to be used or, as in the case of smoke generators, the volume in cubic feet covered by each unit.
4. The extent and characteristics of the insect population.

Dosages for most WP's and EC's used in the greenhouse are given on the labels in ounces per 100 gallons of water and the resulting spray formulations are applied to plant material up to the run off point. Aerosol labels indicate the length of time the nozzle should be directed at the plant material for the delivery of the necessary dosage. Smokes state the volume in cubic feet of greenhouse covered by one generator.

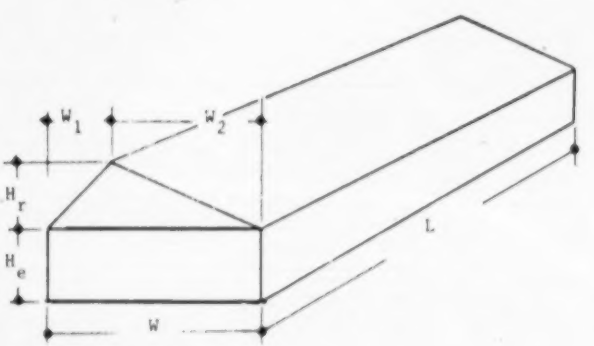
Once the rate of pesticide has been established from the label, the volume of the greenhouse or the area requiring treatment must be determined if using smoke generators, foggers, and mist generators.

The following diagrams illustrate how to determine the volume (in cubic feet) of several styles of greenhouses.



For even-span greenhouses:

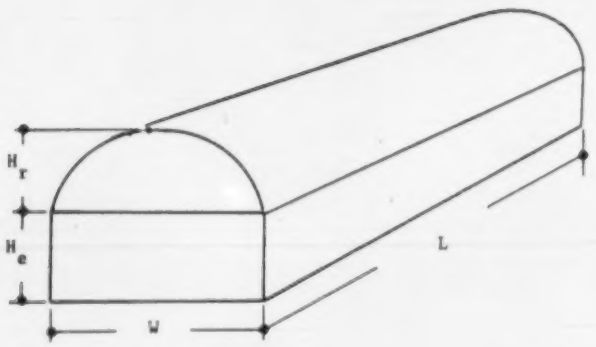
$$\text{greenhouse volume in cubic feet} = \left[(W \times H_e) + \frac{W \times H_r}{2} \right] \times L$$



For uneven-span greenhouses:

$$\text{greenhouse volume in cubic feet} = \left[(W \times H_e) + \frac{W_1 \times H_r}{2} + \frac{W_2 \times H_r}{2} \right] \times L$$

37



For Quonset structures: A

$$\text{greenhouse volume in cubic feet} = \left[(H_e \times W) + \frac{3.14 \times H_r \times H_r}{2}\right] \times L$$

For Quonset structures: B

$$\text{greenhouse volume in cubic feet} = \left[\frac{3.14 \times H_r \times H_r}{2}\right] \times L$$

When using sprays and aerosols, or when making soil applications of pesticides, determine the square feet of planted area to be treated. This is established by determining the sum total of all bench space or production floor area which will be treated. Note: if plants will be treated with a spray to the "run off" point, calculation of the area involved may not be necessary, but, for the same area, the volume of spray required for proper coverage will vary with the type and height of the plant material. Aerosol directions often indicate the number of seconds the generator should be directed at a given type of plant material.

After the pesticide rate and the size of the area to be treated are established, the capacity of the equipment must be determined. In the case of smokes and aerosols, pesticide and equipment are self-contained. Foggers and mist blower equipment provide instructions for filling with concentrated pesticide, based on greenhouse volume.

When sprays are involved, equipment capacity must be established. If the gallon capacity of the sprayer tank is not known, one of the following caculations can be used:

TYPE OF TANK	CALCULATION OF CAPACITY
Cylinder tank (circular cross-section)	Multiply length in inches by square of diameter in inches; then multiply by 0.0034.
Tank with elliptical cross-section	Multiply length in inches by short diameter (d_2) in inches by long diameter (d_1) in inches; then multiply by 0.0034.
Rectangular tank (square or oblong cross-section)	Multiply length by width by depth, all in inches; then multiply product by 0.004329.

After the capacity of the spray tank is established, the correct amount of pesticide concentrate to use must be calculated. Many of the tanks have a capacity of less than 100 gallons, although this is the figure generally mentioned on pesticide labels. The following formula may be used to determine the amount of concentrate to add to a tank of less than 100 gallons:

$$\frac{\text{amount of concentrate (in ounces) recommended for 100 gallons}}{\text{100 gallons}} \text{ X } \text{capacity of the tank (in gallons)}$$

$$= \text{amount of concentrate to use (in ounces)}$$

For example: If 3 pounds of a wettable powder are recommended for 100 gallons of spray, how many pounds of WP are required for a 25-gallon tank?

Note: First convert the 3 lbs. to ounces: 3 lbs. = 48 oz.

$$\frac{48 \text{ oz.}}{100 \text{ gals.}} \text{ X } 25 \text{ gallons} = 12 \text{ oz.}$$

When a presticide is given at a dosage rate per acre, the portion of an acre to be treated must first be determined.

Example 1: An insecticide is recommended at 2 gallons per acre. How much should be used on a 10,000 sq. ft. area?

Calculation: $\frac{10{,}000 \text{ sq. ft.}}{43{,}560 \text{ sq. ft./acre}} = .2295$ acre (converting 10,000 sq. ft. to acres)

1 gallon = 128 fluid oz. 2 gallons = 256 fluid oz.

Multiply the recommended rate in ounces by the acreage to be covered:

2 gallons X 10,000 sq. ft. = 256 oz. X .2295 acre = 58.75 fluid ounces of pesticide for 10,000 sq. ft.

Example 2: A granular pesticide is recommended at a rate of 15 lbs. per acre. How much should be applied to 100 sq. ft.?

Calculations: $\frac{100 \text{ sq. ft.}}{43{,}560 \text{ sq. ft./acre}} = .002295$ acre

15 lbs. = 240 oz.

Multiply the recommended rate by the acreage covered:

240 oz. X .002295 acres = .5509 oz. = 15.6 grams

The tables below can be used when preparing pesticide spray formulations of Wettable Powders (WP) or liquid concentrations of Emulsifiable Concentrates (EC) in volumes of water less than 100 gallons.

Example 1: (Use chart 1.) If the label specifies 3 lbs. of wettable powder in 100 gallons of water, then 3 tablespoons of the same wettable powder will be needed to make a one gallon spray formulation.

Example 2: (Use chart 2.) If the label specifies 3 pts. of liquid concentrate in 100 gallons of water, then 4½ teaspoons of the same preparation will be needed to make a one gallon spray formulation.

CHART 1

Water	Quantity of Wettable Powder Pesticide Needed					
100 gal.	1 lb.	2 lbs.	3 lbs.	4 lbs.	5 lbs.	6 lbs.
50 gal.	½ lb.	1 lb.	1½ lb.	2 lbs.	2½ lbs.	3 lbs.
25 gal.	¼ lb.	½ lb.	¾ lb.	1 lb. .	1¼ lbs.	1½ lbs.
5 gal.	5 T.	10 T.	15 T. or 1 cup	20 T. or 1¼ cup	25 T. or 1⅓ cup	30 T. or 1¾ cup
1 gal.	1 T.	2 T.	3 T.	4 T.	5 T.	6 T.

CHART 2

Water	Quantity of Liquid Concentrate Pesticide Needed					
100 gals.	½ pt.	1 pt.	2 pts.	3 pts.	4 pts.	5 pts.
50 gals.	¼ C.	½ pt.	1 pt.	1½ pts.	2 pts.	2½ pts.
25 gals.	2 fl. oz.	4 fl. oz.	1 C.	1½ C.	1 pt.	1¼ pts.
5 gals.	1 T.	2 T. or 1 fl. oz.	4 T. or 2 fl. oz.	6 T. or 3 fl. oz.	8 T. or 4 fl. oz.	10 T. or 5 fl. oz
1 gal.	¾ t.	1½ t.	3 t.	4½ t.	6 t. or 2 T.	7½ t.

T. = tablespoon t. = teaspoon C. = cup fl. oz. = fluid ounce

EQUIVALENTS HELPFUL FOR THE MEASUREMENT OF SMALL QUANTITIES OF LIQUID MATERIAL

Gallons	Quarts	Pints	Fluid Ounces	Cups	Tablespoons	Teaspoons	Milliliters (cubic centimeters)
1	4	8	128	16			
	1	2	32	4			
		1	16	2	32		
			1	1/8	2	6	30
				1	16	48	240
					1	3	15
						1	5

3 teaspoons	=	1 tablespoon				
2 tablespoons	=	1 fluid ounce	=	6 teaspoons		
4 tablespoons	=	12 teaspoons	=	¼ cup	=	2 fluid ounces
1 cup	=	16 tablespoons	=	8 fluid ounces		
2 cups	=	32 tablespoons	=	1 pint	=	16 fluid ounces
2 pints	=	64 tablespoons	=	1 quart	=	4 level cups
4 quarts	=	8 pints	=	1 gallon	=	16 level cups

To secure accuracy of measurement of liquid material, the purchase of graduated cylinders of 100 and 500 milliliter (cubic centimeter) capacity is strongly suggested.

APPLICATION RATES OF ACTIVE INGREDIENT PER ACRE FOR VARIOUS CONCENTRATIONS OF EMULSIFIABLES, WETTABLES, AND DUSTS

Amount of Actual Chemical Recommended Per Acre

Pounds of active chemical recommended per acre:									
1/8	1/4	1/2	3/4	1	1 1/2	2	2 1/2	3	5
Amount of formulation needed to obtain the above amounts of active chemical for:									
10%-12% Emulsion Concentrate (contains 1 pound chemical per gallon)									
1 pt	1 qt	2 qt	3 qt	1 gal	1 1/2 gal	2 gal	2 1/2 gal	3 gal	5 gal
15%-20% Emulsion Concentrate (contains 1 1/4 pounds chemical per gallon)									
1/3 qt	2/3 qt	1 1/3 qt	2 qt	2 2/3 qt	1 gal	1 1/3 gal	1 2/3 gal	2 gal	3 2/5 gal
25% Emulsion Concentrate (contains 2 pounds chemical per gallon)									
1/2 pt	1 pt	1 qt	3 pt	2 qt	3 qt	1 gal	5 qt	1 1/2 gal	2 1/2 gal
40%-50% Emulsion Concentrate (contains 4 pounds chemical per gallon)									
1/4 pt	1/2 pt	1 pt	1 1/2 pt	1 qt	3 pt	2 qt	5 pt	3 qt	5 qt
60%-65% Emulsion Concentrate (contains 6 pounds chemical per gallon)									
1/6 pt	1/3 pt	2/3 pt	1 pt	1 1/3 pt	1 qt	2 2/3 pt	3 1/3 pt	2 qt	3 1/3 qt
70%-75% Emulsion Concentrate (contains 8 pounds chemical per gallon)									
1/8 pt	1/4 pt	1/2 pt	3/4 pt	1 pt	1 1/2 pt	1 qt	2 1/2 pt	3 pt	2 1/2 qt
15% Wettable Powder									
3/4 lb	1 1/2 lb	3 1/3 lb	5 lb	6 2/3 lb	10 lb	13 1/2 lb	16 2/3 lb	20 lb	33 1/3 lb
25% Wettable Powder									
1/2 lb	1 lb	2 lb	3 lb	4 lb	6 lb	8 lb	10 lb	12 lb	20 lb
40% Wettable Powder									
5 oz	10 oz	1 1/4 lb	1 7/8 lb	2 1/2 lb	3 3/4 lb	5 lb	6 1/4 lb	7 1/2 lb	12 1/2 lb
50% Wettable Powder									
1/4 lb	1/2 lb	1 lb	1 1/2 lb	2 lb	3 lb	4 lb	5 lb	6 lb	10 lb
75% Wettable Powder									
1/6 lb	1/3 lb	2/3 lb	1 lb	1 1/3 lb	2 lb	2 2/3 lb	3 1/3 lb	4 lb	6 2/3 lb
80% Wettable Powder									
2 1/2 oz	5 oz	5/8 lb	15/16 lb	1 1/4 lb	1 7/8 lb	2 1/2 lb	3 1/8 lb	3 3/4 lb	6 1/4 lb
1% Dust									
12 1/2 lb	25 lb	50 lb	75 lb	100 lb	150 lb	200 lb	250 lb	300 lb	500 lb
5% Dust									
2 1/2 lb	5 lb	10 lb	15 lb	20 lb	30 lb	40 lb	50 lb	60 lb	100 lb
10% Dust									
1 1/4 lb	2 1/2 lb	5 lb	7 1/2 lb	10 lb	15 lb	20 lb	25 lb	30 lb	50 lb

Example shown: If 1 lb. active ingredient is recommended per acre and a 40%-50% emulsion concentrate is used, then 1 qt. of the formulated material is required per acre.

THE METRIC SYSTEM

Within the next 10 years, the use of the metric system of measurement will increase in the United States. Since label instructions will be shown in metric measurements applicators will need to familiarize themselves with this system and its U.S. equivalents.

The metric system is based on the decimal system. The basic units are:

meter = 3.28 ft. = 39.37 in. (a little longer than a yard)
liter = 33.8 fl. oz. (a little larger than a quart)
gram = 0.0353 oz. (about the weight of a paper clip)

Common prefixes used with these basic metric units are:

milli: one-thousandth (0.001)
- 1000 millimeters = 1 meter
- 1000 milliliters = 1 liter
- 1000 milligrams = 1 gram

centi: one-hundredth (0.01)
- 100 centimeters = 1 meter
- 100 centiliters = 1 liter
- 100 centigrams = 1 gram

deci: one tenth (0.1)
- 10 decimeters = 1 meter
- 10 deciliters = 1 liter
- 10 decigrams = 1 gram

deca: ten times (10)
- 1 decameter = 10 meters
- 1 decaliter = 10 liters
- 1 decagram = 10 grams

hecto: one hundred times (100)
- 1 hectometer = 100 meters
- 1 hectoliter = 100 liters
- 1 hectogram = 100 grams

kilo: one thousand times (1000)
- 1 kilometer = 1000 meters
- 1 kiloliter = 1000 liters
- 1 kilogram = 1000 grams

Some useful measures and metric equivalents are:

Linear measures:

one inch = 2.54 centimeters = 25.4 millimeters
one millimeter = 0.0394 in. = about 1/25 in. = 1.000 microns
one centimeter = 10 millimeters = 0.3937 in. = about 2/5 in.
one meter = 100 centimeters = 1000 millimeters = 3.28 ft. = 39.37 in.
one kilometer = 1000 meters = 0.6214 mile

Area measures:

1 sq. centimeter = 100 sq. millimeters = 0.15499 sq. in.
1 sq. decimeter = 100 sq. centimeters = 15.499 sq. in.
1 sq. meter = 1 centiare = 100 sq. decimeters = 1,549.9 sq. in. or 1.196 sq. yards
1 are = 100 sq. meters = 119.6 square yards
1 hectare = 100 ares = 10,000 sq. meters = 2.471 acres
(centiare, are, and hectare are used in land measurements)
1 sq. ft. = 144 sq. in. = 0.0929 sq. meter
1 sq. yd. = 9 sq. ft. = 0.8361 sq. meter
1 acre = 43,560 sq. ft. = 0.4047 hectare

Weight measures:

1,000 milligrams = 1 gram = 0.03527 ounce = 15.432 grains
1,000 grams = 1 kilogram = 2.2046 lbs.
1,000 kilograms = 1 metric ton = 2,204.6 lbs.
1 dram = 17,718 grams
1 ounce = 16 drams = 28.3495 grams
1 pound = 16 ounces = 453.59 grams

Liquid measures:

1 fluid ounce = 29.5729 milliliters
1 pint = 16 fluid ounces = 473.167 milliliters
1 quart = 2 pints = 32 fluid ounces = 946.33 milliliters
1 gallon = 4 quarts = 8 pints = 128 fluid ounces = 3.7853 liters
1 liter = 1000 milliliters = 1.0567 quarts = 33.8 fluid ounces

Volume measures;

1000 cubic millimeters = 1 cubic centimeter = 0.06102 cu. in.
1000 cubic centimeters = 1 cubic decimeter = 61.02 cu. in.
1000 cubic decimeters = 1 cubic meter = 35.14 cu. ft.

USEFUL CONVERSION FACTORS FOR COMMON MEASUREMENT UNITS

Type of measurement	Multiply	By	To convert to
Length	inches	25.4	millimeters
	feet	30.48	centimeters
	yards	0.9144	meters
	miles (statute)	1.609	kilometers
	millimeters	0.03937	inches
	centimeters	0.03281	feet
	meters	1.094	yards
	kilometers	0.6214	miles
Area	square inches	6.452	square centimeters
	square feet	0.0929	square meters
	square yards	0.8361	square meters
	square miles	2.59	square kilometers
	acres	0.4047	square hectometers (hectares)
	square centimeters	0.155	square inches
	square meters	10.76	square feet
	square meters	1.196	square yards
	square kilometers	0.3861	square miles
	square hectometers (hectares)	2.471	acres
Mass weight	ounces	28.3495	grams
	pounds	0.4536	kilograms
	short tons	0.9078	megagrams (metric tons)
	grams	~~0.3527~~ 0.03527	ounces
	kilograms	2.205	pounds
	megagrams (metric tons)	1.1016	short tons
Liquid volume	ounces	29.59	milliliters (cubic centimeters)
	pints	0.4732	liters
	quarts	0.9463	liters
	gallons	3.785	liters
	milliliters (cubic centimeters)	0.0338	ounces
	liters	2.113	pints
	liters	1.057	quarts
	liters	0.2642	gallons
Temperature	degrees Farenheit (°F)	5/9 after subtracting 32	degrees Celsius (°C)
	degrees Celsius	9/5 then add 32	degrees Farenheit

THE SAFE USE OF TEMIK

Temik (R) (aldicarb), a highly toxic carbamate pesticide with systemic action, is available in a granular form for use *strictly as a soil treatment* and *only by trained personnel.* It has received Federal registration only for the control of spider mites, aphids, thrips, mealybugs, whiteflies and leaf miners for the following ornamentals grown in commercial greenhouses: Chrysanthemums, Orchids (Cymbidiums), Easter Lilies, Poinsettia, Gerbera, Carnations, Roses, and Snapdragons.

Temik has also received registration for use as a soil insecticide *by trained personnel only*, on *commercially* field grown Roses, Dahlias, Lilies, Bulbs, Birches and Hollies. WE STRONGLY DISCOURAGE THE USE OF TEMIK UNDER OUTDOOR CONDITIONS IN MASSACHUSETTS, AS OUR SUBURBAN TYPE OF AGRICULTURE ACCENTUATES THE HAZARDS THAT MAY ARISE FROM THE IMPROPER USE OF THIS HIGHLY TOXIC PESTICIDE.

We suggest that growers and their properly trained personnel become familiar with the safest and most accurate methods recommended for handling and delivering the Temik granules under given cultural and greenhouse conditions. Applications of granules in excess of recommended rates may delay handling and marketing of the treated crops, cause injury to the crops, and, most important, be highly hazardous to personnel and consumers. Unless an accurate measuring device is available for measuring the delivery of small amounts of Temik granules, we strongly discourage the treatment of individual flower pots.

Temik is applied to potted plants at a rate of one-eighth of a teaspoon per six inch pot. Several methods have been devised for measuring small amounts of granules with approximate accuracy. Some growers have fashioned devices measuring fractions of a teaspoon. Shotgun loaders can also be modified to dispense granules. A short length of hose can be clamped to the bottom to direct the Temik particles into the pots.

When equipment for delivery of small amounts of granules is unavailable, it is suggested that applications of Temik, at rates indicated on the label, under greenhouse conditions, be limited to "planted" beds and to large numbers of closely spaced "planted" pots forming a continuous soil surface measurable in square feet units. Treated plants should not be removed from the area of application or handled for two weeks, and during this period the pots should be thoroughly and frequently watered.

For treating "planted" beds or closely spaced "planted" pots, a coffee or other large can or container with holes punched in the bottom may be used. When the container is filled with granules, a plastic lid or other cover should be used to control dust. The Temik is then distributed as uniformly as possible over the "planted" bed or "planted" pots by walking up and down along the outer sides of the target area while shaking the container. After the Temik has been applied, the treated area should be watered with at least ½ inch of water and all granules washed off the plant foliage. Temik should always be applied to dry plant foliage. The practice of applying granules to wet foliage is hazardous and does not reflect label recommendations. Care should be taken not to allow granules to fall on non-target areas, and not to flood the floor and walking paths.

The mixing of granules with sand to increase the volume of the pesticide in the delivery devices is not recommended because of hazards and because stratification will occur due to the differences in specific gravity. *Temik granules must never be mixed with water;* the solution that arises is extremely hazardous.

Commercial growers who use Temik should observe the following precautionary rules strictly:

1. Do not use Temik on ornamental crops not listed on the label.

2. Do not treat or contaminate edible crops, or soil and equipment to be used in growing edible crops, with Temik.

3. Temik is highly toxic to humans and animals. Since it is rapidly absorbed through the skin, eyes, and nose, and since the dust is extremely hazardous, do not use any mechanical device that will crush the granules and produce dust. (The chemical was formulated in granular form for your protection.)

4. *Only trained personnel should be allowed to use Temik.* They should be provided with and wear long-sleeved overalls, gloves, a respirator with filter pads and chemical cartridges, and goggles. Do not allow granules to land on shoes, socks or in trouser cuffs, and above all, on skin. Wash all clothing and entire body after handling Temik.

5. Temik should not be used in areas to which untrained personnel, customers, and visitors have access, or places accessible from retail areas and habitations. Temik must not be used near or on residential grounds, food handling areas, animal shelters, edible crops, forage crops, bodies of water, recreational grounds, etc. Treated areas in the greenhouse should be clearly posted with the date of application and the name of the chemical.

6. Store Temik in its original bag in a hard and air-tight container *under lock*, and above all, away from habitations, food storage areas, and places frequented by humans and animals.

7. *Do not allow handling of treated plants for a period of 2 weeks from the day of application.* During this period, activities such as transplanting, thinning, disbudding and other activities requiring contact with the treated soil and plants may be hazardous.

8. *Carefully water treated soil at once [do not apply Temik to dry soil] and wash granules off foliage at once. Do not apply Temik to plants in the late bud and blossom stages.* The ability of taking up and translocating Temik is greatly diminished in plants in these late stages of development.

9. *Never* mix Temik with potting soil or apply Temik to soil prior to transplanting, seeding, or any other operations that may require the handling of treated soil and equipment.

10. *Do not market plants within 4 weeks from application, provided that you do not exceed label recommendations.*

11. Read the label for the disposal of containers and chemicals and the handling of accidental spillage and exposure.

In emergency cases, contact the Union Carbide Corp. at the numbers listed below:

Dr. C.V. Dernehl:	212-551-4785, 914-946-0646
Dr. K.S. Lane:	212-551-4787, 914-666-3656
Dr. C.P. Carpenter:	412-327-1020, 412-241-7896

A METHOD OF DELIVERY FOR SMALL AMOUNTS OF TEMIK GRANULES

There is an accurate, rapid, safe and inexpensive method of dispensing small quantities of Temik by using a powder measure. Powder measures are available in most local gun shops. One, available in this area, that has been called to our attention is the Lyman Powder Measure, No. 55, by Lyman Products, Middlefield, Conn. 06455.

Table 1. Settings of "Lyman No. 55 Powder Measure" for deliverance of Temik 10% granular at rates of 20 - 30 and 40 ozs. of formulation/1000 square feet of soil surface to pots 6 to 12 inches in diameter (see Table 2 for gram equivalents). These settings are approximate in accuracy and applicable only to granule size presently marketed. Check deliverance of purchased equipment with the aid of Table 2.

GAUGE SETTINGS

Pot Size Inches	20 ozs./1000 sq. ft.	30 ozs./1000 sq. ft.	40 ozs./1000 sq. ft.
6	4.25 front scale	6.0 front scale	7.25 front scale
7	5.0 front scale	7.25 front scale	9.25 front scale
8	6.25 front scale	9.0 front scale	10.75 front scale
9	8.0 front scale	10.5 front scale	13.5 front scale
10	9.25 front scale	13.0 front scale	15.75 back scale
11	10.5 front scale	15.0 front scale	18.0 back scale
12	13.0 front scale	18.25 back scale	22.25 back scale

NOTE: Before setting gauge, screw in lower slide first and upper slide second. Each slide should be screwed in flush with end lip of track of inner channel (inside well of equipment).

Table 2. Grams of Temik 10% granular per individual pot 6 to 12 inches in diameter at application rates of 20 - 30 and 40 ozs. of formulation/1000 sq.ft. of soil surface.

Pot Size Inches	20 ozs./1000 sq. ft.	30 ozs./1000 sq. ft.	40 ozs./1000 sq. ft.
6	.110 gms.	.167 gms.	.223 gms.
7	.150 gms.	.227 gms.	.304 gms.
8	.196 gms.	.296 gms.	.397 gms.
9	.248 gms.	.375 gms.	.502 gms.
10	.306 gms.	.463 gms.	.620 gms.
11	.371 gms.	.560 gms.	.750 gms.
12	.441 gms.	.667 gms.	.893 gms.

Use Pesticides Safely

FOLLOW THE LABEL

U.S. DEPARTMENT OF AGRICULTURE

TOXICITY OF PESTICIDES

Many of the pesticides listed below are not registered for greenhouse use. Letters in parentheses indicate the class of pesticide as follows: (A)-acaracide, (F)-fungicide, (FUM)-fumigant, (H)-herbicide, (I)-insecticide, and (M)-molluscicide.

HIGHLY TOXIC: Acute* oral LD50 (to rats) from 0 - 50 +mg/kg. The label of the majority of these pesticides shows the signal words "Danger — Poison" (printed in red) and the skull and crossbones. (From a taste to 7 drops could be lethal to a 150 lb. man.)

COMMON NAME OF CHEMICAL	TRADE NAME	TYPE OF COMPOUND	ACUTE* ORAL (mg/kg)	ACUTE* DERMAL (mg/kg)
Cyanides (Fum)	Cyanogas	calcium cyanide	extremely toxic	extremely toxic
Chloropicrin (Fum)			LC50.8 mg/liter	severe irritation
Methyl bromide (Fum)			LC50-1 mg/liter	extremely toxic
Aldicarb (I)	Temik	carbamate	0.93	2.5
TEPP (I)		phosphate	1.05	2.4
Phorate (I)	Thimet	phosphate	1-3	3.6
Cyclohexamide (F)	Acti-dione PM		2	extremely toxic
Demeton (I)	Systox	phosphate	2-6	8-14
Disulfoton (I)	Di Syston	phosphate	2-7	6-15
Fensulfothion (I)	Dasanit	phosphate	2-11	3-30
Mevinphos (I)	Phosdrin	phosphate	4-6	4-5
Parathion (I)		phosphate	4-13	7-21
Sulfotepp (I)	Dithio	phosphate	5	8
Carbofuran (I)	Furadan	carbamate	5	885
Fonofos (I)	Dyfonate	phosphate	8-17.5	25
EPN (I)	EPN-300	phosphate	8-36	25-230
Carbophenothion (I)	Trithion	phosphate	10-30	27-54
Arsenic compounds (I)			10-50	Toxic
Azinphosmethyl (I)	Guthion	phosphate	11-13	220
Methyl parathion (I)		phosphate	14-24	67
Methomyl (I)	Lannate	carbamate	17-24	1500
Endosulfan (I)	Thiodan	hydrocarbon	18-43	74-130
Methamidophos (I)	Monitor	phosphate	18.9-21	118
Monocrotophos (I)	Azodrin	phosphate	20	342
Phosphamidon (I)	Dimecron	phosphate	20-22.4	107-143
Dioxathion (I)	Delnav	phosphate	23-43	63-235
Mexacarbate (I)	Zectran	carbamate	25-37	1500-2500
Methidathion (I)	Supracide	phosphate	25-48	375
Ethion (I)	Nialate	phosphate	27-65	62-245
Dinitro compounds (F,I,H)	DNOC	dinitro phenol	30	150-600 (guinea pig)
Oxamyl (I,N,A)	Vydate		37	2960 (rabbit)
Dieldrin (I)		hydrocarbon	46-60	60-100
Coumaphos (I)	Co-Ral	phosphate	56	860
Nicotine sulfate (I)		alkaloid	83	285
Paraquat (H)			120	480

* Acute poisoning — Severe poisoning which occurs after a single exposure to the pesticide.
Chronic poisoning — Poisoning which occurs as a result of repeated exposures to small doses of the pesticide over a long period of time.

MODERATELY TOXIC: Acute* oral LD50 (to rats) from 50 - 500 mg/kg.
The label of these pesticides shows the signal word "Warning".

Kerosene		solvent	50 for comparison	
Rotenone (I)		botanical	50-75	950+ rabbit
Pentachlorophenol (H,I)	PCP		50-140	mild reaction
Dichlorvos (I)	Vapona	phosphate	56-80	75-107
Oxydemeton-methyl (I)	Meta-Systox-R	phosphate	65-76	250
Bux (I)	Bux-Ten	carbamate	87-170	400 rabbit
Lindane (I)		hydrocarbon	88-125	1000
Arprocarb (I)	Baygon	carbamate	95-100	1000
Crotoxyphos (I)	Ciodrin	phosphate	125	385 rabbit
Pirimicarb (I)	Pirimor	carbamate	147	-----
Chlorpyrifos (I)	Dursban	phosphate	163	-----
Chlordimeform (I)	Fundal & Galecron		162-170	255
Aromatic solvents		solvent	170	-----
dimethoate (I)	Cygon	phosphate	215	400-610
Fenthion (I)	Baytex	phosphate	215-245	330
Chlordimeform hydrochloride (I)	Fundal & Galecron		225-280	4000+ ----
Naled (I)	Dibrom	phosphate	250	800
Dichlonfenthion (N,I)	VP-13 Nemacid	phosphate	250-270	6,000
Metaldehyde (M)		hydrocarbon	250-1000	----
Phosmet (I)	Imidan	phosphate	300	3160
Vorlex (Fum)	Vorlex		305	----
Diazinon (I)	Diazinon	phosphate	300-400	455 500
Chlordane (I)		hydrocarbon	335-430	690-840
Diquat (H)			400-440	500+
2,4,5-T (H)			481-500	mild reaction
Fenithrothion (I)	Sumithion	phosphate	500	1300
Plictran (A)			540	2000+

LOW TOXICITY: Acute* oral LD50 above 500 mg/kg. The label of these pesticides shows the signal word "Caution".

Carbaryl (I)	Sevin	carbamate	500-850	4000+
Petroleum solvents		solvent	about 510	----
Crufomate (I)	Ruelene	phosphate	548	3000
Trichlorfon (I)	Dylox-Dipterex	phosphate	560-630	2000+
Ethylene dichloride (Fum)			670-890	3890 rabbit
Formaldehyde	Formalin		800	mild reaction
Metam-Sodium (Fum)	Vapam	carbamate	820	800
Dicofol (A)	Kelthane	hydrocarbon	809-1100	1000
Acephate (I)	Orthene	phosphate	945	----
Chlorobenzilate (A)	Acaraben	hydrocarbon	960-1220	5000+
Morestan (A,F)		carbonate	1100-1800	2000+
Ryania (I)		botanical	1200	4000+ rabbit
Pyrethrum (I)		botanical	1345	2060 rabbit
Ammonium sulfamate (H)	Ammate X		1600-3900	mild reaction
Ronnel (I)	Korlan	phosphate	1940	5000+
Temophos (I)	Abate	phosphate	2000	2000
Kinoprene (I)	Enstar	insect growth regulator	2330	9000 rabbit
Propargite (A)	Omite	sulfite	2500	----
Pentac (A)		hydrocarbon	3160	3160+ rabbit
Trifluralin (H)	Treflan E		3700-10,000	5000
Tetrachlorvinphos (I)	Gardona, Rabon	phosphate	4000-5000	5000+ rabbit
Resmethrin (I)	SBP 1382	synthetic pyrethroid	4240	3040+
Chloropropylate (A)	Acaralate	hydrocarbon	5000	10,200+ rabbit
Methoxychlor (I)	Marlate	hydrocarbon	5000	6000+
Perthane (I)		hydrocarbon	8170	----
Benomyl (F)	Benlate	carbamate	9590	little reaction
Tetradifon	Tedion	hydrocarbon	14,700	10,000
Bacillus thuringiensis	Dipel, Biotrol, Thuricide	bacteria	harmless	harmless

FEDERAL INSECTICIDE FUNGICIDE AND RODENTICIDE ACT — CATEGORIES OF TOXICITY

		ROUTE OF ADMINISTRATION			
		LD_{50}			LC_{50}
CATEGORY	SIGNAL WORD ON THE LABEL	ORAL (mg/kg)[1]	Probable Oral Dose for a 150 lb. man	DERMAL (mg/kg)[1] 24 hour exposure	INHALATION (µg/1)[2]
I (HIGHLY TOXIC)	DANGER — skull and crossbones — POISON	0 to 50	a few drops to a teaspoonful	0 to 200	0 to 2,000
II (MODERATELY TOXIC)	WARNING	over 50 to 500	over one teaspoonful to one ounce	over 200 to 2,000	over 2,000 to 20,000
III (SLIGHTLY TOXIC)	CAUTION	over 500 to 5,000	over one ounce to one pint or one pound	over 2,000 to 20,000	
VI (RELATIVELY NONTOXIC)	none*	over 5,000	over one pint or one pound	over 20,000	

NOTE: * None required based on acute toxicity; however, nature of product and use pattern may require appropriate precautionary statements.

LD_{50} — the dose level which will kill 50% of test animals. Minimum of 14 days observation. Animals fasted for oral studies.

LC_{50} — the air concentration which will kill 50% of test animals exposed for a period of 1 hour. Minimum of 14 days observation. Vapor or gas may be expressed in ppm.

[1]Equivalents: 1000 milligrams (mg) = 1 gram (g); 28.3 grams = 1 ounce; 1 kilogram (kg) = 2.2 pounds (lb)

[2]Equivalents: 1 liter (l) = 1.06 quarts; 1000 micrograms (µg) = 1 milligram (mg)

READ THE LABEL

REPORTED PHYTOTOXICITY OF ACARICIDES AND INSECTICIDES TO ORNAMENTALS*

Injury to plant material after pesticide applications may manifest itself in a variety of ways. The most common are: total burn, marginal burn or spotting of foliar and/or flower parts; cupping, curling and chlorosis of foliage; and distortion of foliar and flower buds. Soil applications of insecticides may also produce these symptoms, as well as stunting of growth because of injury to the root system of the plant. Severe root injury will cause sudden wilting and death of the aerial parts of the plant. As a rule, flowers and flower buds in advanced stages of development are highly susceptible to pesticide injury. Aerosol applications are usually less phytotoxic to blossoms and breaking flower buds. Smoke formulations are usually safer than mists and fogs, provided label instructions are followed carefully.

The incidence of spray damage to plants may be minimized by applying the pesticide (at the rate indicated on the label) during the cooler hours of the day and to dry plants in a well-ventilated greenhouse. Wettable, suspensible and flowable powders are generally less phytotoxic to plants than emulsifiable concentrates, although the former may leave an unsightly residue.

To avoid the kinds of damage described above it is important to consult the pesticide labels, which in many instances indicate specifically those plants which are sensitive to the pesticide and those for which it is specifically recommended.

It should be understood that none of the chemicals presently marketed has been evaluated for phytotoxicity on all available ornamentals. Moreover, variations in growing conditions may produce different phytotoxicity results for the same chemical. It is therefore strongly recommended that a new pesticide or a well-known one selected for application to new plant material should always be evaluated on a trial basis on a small number of plants representing the material to be protected. The toxic effects of spray applications to foliage and to flower parts should become evident within 5 to 10 days.

It is advisable to avoid closely spaced pesticide applications of one or more pesticides because residue build-up and/or chemical incompatibility may result in plant injury.

Unregistered tank mixtures of two or more pesticides may cause damage to target plants which does not occur when the chemicals are used individually.

It is suggested that applicators of pesticides become acquainted with whatever is known on the phytotoxicity of pesticides. The authors have attempted to be helpful in this manner by providing the information which follows and which was derived from an extensive literature search related to reported injury to ornamentals from acaricides and insecticides. Unless otherwise indicated, the plant injury resulted from spray or mist applications to the foliage.

* From: Florogram, Volume ix, Number 3, May-June 1976, Cooperative Extension Service Suburban Experiment Station, Waltham, Mass.

Prepared by S. M. Richman and A. G. Gentile

The grower should verify whether the chemicals listed below have received Federal or State clearance for use under greenhouse conditions.

ACARABEN* (chlorobenzilate)
- Chrysanthemum (injurious to blossoms of var. "Nob Hill")
- Gloxinia
- *Hydrangea spp.*
- *Kalanchoe spp.*
- Poinsettia (injurious to the bracts of var. Paul Mikkelsen" and "Mikkelwhite")
- *Prunus spp.*
- Rose
- Do not use with sulfur

ANTHIO* (formothion)
- *Achimenes longiflora*
- *Adiantum sp.* (Maidenhair fern)
- *Aeschyanthus lobbianus*
- *Anthurium scherzerianum*
- *Aralia spp.*
- *Begonia spp.*
- Chrysanthemum
- *Cineraria spp.*
- *Coleus spp.*
- *Ficus spp.*
- *Gerbera jamesonii*
- Gloxinia
- *Zinnia spp.*

BAYTEX* (fenthion)
- Rose (var. "Delightful")

CYGON* (dimethoate)
- *Acacia notabilis*
- *Anthurium spp.*
- *Anthurium scherzerianum*
- *Aphelandra spp.*
- *Aphelandra squarrosa*
- *Aralia spp.*
- Azalea (var. "Carmen", "Stewartstonian" and "Palustrina")
- *Begonia spp.*
- *Begonia maculata*
- *Brassaia actinophylla* (Schefflera)
- *Broughtonia spp.*
- *Calanthe spp.*
- *Calceolaria spp.*
- Carnation
- *Chamaedorea elegans* (Neanthe Bella Palm)
- Chinese holly
- *Chrysanthemum indicum*
- *Cineraria spp.*
- *Cissus spp.*
- *Cissus antartics* (Kangaroo Vine)
- *Coleus spp.*
- *Cyclamen spp.*
- *Cycnoches dentricosum*

* Trade Name

CYGON* (dimethoate) Continued
Dendrobium moschatum
Dendrobium pulchellum
Dendrobium phalaenopsis
Dieffenbachia spp.
Euphorbia spp.
Fatshedera Ivy
Fatsia japonica
Ferns (no specific identification)
Ficus spp.
Ficus nitida
Freesia spp.
Fuchsia spp.
Geranium
Gerbera jamesonii
Gloxinia
Hibiscus spp.
Hydrangea spp.
Iris spp.
Jacobinia spp.
Lilium longiflorum
Maranta sp. (Prayer Plant)
Neomoorea irrorata
Nephrolepis exaltata (Florida Ruffle Fern)
Pandurata spp.
Peperomia obtusifolia
Philodendron spp.
Pilea cadierei
Podocarpus macrophylla
Poinsettia (injurious to bracts of var. "Paul Mikkelsen" and "Mikkelwhite")
Polyanthes
Primula spp.
Prunus spp. (ornamental)
Rochea
Rose
Saintpaulia ionantha
Streptocarpus spp.
Zantedeschia spp.
Zinnia spp.

DIAZINON*
Adiantum cuneatum (Maidenhair fern)
Anthurium spp.
Anthurium scherzerianum
Asparagus plumosus
Asparagus sprengeri
Asters
Begonia spp.
Brunfelsia spp.
Cacti (no specific identification)
Cissus spp.
Cissus antartica (Kangaroo Vine)
Crepe Myrtle
Cyclamen spp.

DIAZINON* Continued
Cytisus spp.
Dianthus spp.
Dracaena sanderiana
Euphorbia pulcherrima
Euphorbia splendens
Ferns (no specific identification)
Gardenia jasminoides
Gloxinia
Hedera spp.
Hibiscus spp.
Hoya sp. (Hindu Rope)
Hoya carnosa
Lilium longiflorum
Papaya
Peperomia spp.
Peperomia obtusifolia
Pigmy Date Palm (injurious to roots as a drench)
Pilea spp.
Rose
Saintpaulia spp.
Scindapsus spp.
Stephanotis spp.
Violet

DIBROM* (naled)
Chrysanthemum (var. "Pink Champagne")
Poinsettia
Rose (var. "White Butterfly" and "Golden Rapture")

DIMECRON* (phosphamidon)
Ageratum spp.
Begonia spp.
Chrysanthemum
Cineraria spp.
Coleus spp.
Ferns (no specific identification)
Lilium longiflorum
Primula spp.
Rochea coccinea

DYLOX* (trichlorfon)
Ardisia spp.
Brassaia actinophylla (Schefflera)
Carnation
Chrysanthemum
Dracaena godseffiana (Gold Dust Plant)
Nephrolepis exaltata (Florida Ruffle Fern)
Saintpaulia ionantha (African Violet)
Syngonium podophyllum (var. "Emerald Gem" and "Green Gold") (Nephthytis)

FUNDAL* or GALECRON* (chlordimeform)
Aster (var. "Dwarf Border")
Celosia (var. "Gladiator")
Carnation
Chrysanthemum
Marigold (var. "Petite Orange")
Pansy (var. "Trimardeau")
Zinnia (var. "Dwarf Mexican")

GUTHION* (azinphos-methyl)
Bromeliaceae (no specific identification)
Rose (var. "Roselandia" and "Juletide")

KELTHANE* (dicofol)
Anthurium spp.
Anthurium scherzerianum
Asparagus plumosus
Begonia spp.
Beloperone spp.
Brassaia actinophylla (Schefflera)
Brunfelsia spp.
Chamaedorea elegans (Neanthe Bella Palm)

Chrysanthemum
Cissus spp.
Cissus antartica (Kangaroo Vine)
Codiaeum sp. (Croton)
Collinia elegans
Cordyline sp. (Ti Plant)
Cyclamen spp.
Dianthus spp.
Epiphyllum spp.
Euphorbia
Gardenia jasminoides
Gloxinia
Hedera spp.
Hibiscus spp.
Hibiscus sp. cv. "laterita"
Kalanchoe sp. cv. "Korall"
Peperomia spp.
Poinsettia
Rhoicissus rhomboidea
Rose
Saintpaulia spp.
Schlumbergera gaertneri
Scindapsus sp. (Pothos)
Seedlings (no specific identification)
Sinningia spp.
Stephanotis spp.
Streptocarpus (injured by aerosols)
Sweet Pea

LANNATE* or NUDRIN* (methomyl)
Brassaia actinophylla (Schefflera)
Chrysanthemum
Dracaena godseffiana (Gold Dust Plant)
Peperomia obtusifolia
Pilea cadierei
Rose (var. "Bridal Pink")
Syngonium podophyllum (var. "Emerald Gem") (Nepthytis)

LINDANE*
Acalypha hispida
Achimenes longiflora
Adiantum cuneatum (Maidenhair fern)
Aeschynanthus lobbianus
Ampelopsis heterophylla (injured by aerosols)
Anemone spp.
Anthurium spp.
Aphelandra sp. (Zebra Plant)
Aralia spp.
Asparagus plumosus
Bouvardia spp.
Brunfelsia spp.
Calceolaria spp.
Carnation
Cissus antartica (Kangaroo Vine)
Cyclamen spp.
Dianthus spp.
Dizygotheca elegantissima (False Aralia)
Ficus pumila
Freesia spp.
Fuchsia spp.
Gardenia spp.
Gerbera spp.
Gerbera jamesonii
Gloxinia
Hedera helix
Hibiscus spp.
Hibiscus rosa-sinensis
Hydrangea spp.
Iris spp.
Kalanchoe spp.
Lathyrus spp.
Mathiola spp.
Monstera deliciosa
Narcissus spp.
Pelargonium spp.
Poinsettia
Primula spp.
Rhoeo spp.
Rhoicissus spp.
Rhoicissus rhomboidea
Rose
Saintpaulia spp.
Seedlings (injured by aerosols - no specific identification)
Sinningia spp.
Spathiphyllum spp.
Stephanotis
Tulip

LORSBAN* (chlorpyrifos)
Aphelandra squarrosa (Zebra Plant)
Brassaia actinophylla (Schefflers)
Chrysanthemum (var. "Nob Hill")
Nephrolepsis exaltata (Florida Ruffle Fern)
Tolmiea menziesii (Piggy Back Plant)

MALATHION*
Adiantum spp.
Adiantum cuneatum
Anthurium spp.
Anthurium scherzerianum
Antirrhinum spp.
Aralia spp.
Asparagus plumosus
Asparagus sprengeri
Aster spp.
Begonia spp.
Brassaia actinophylla (Schefflera)
Brunfelsia spp.
Cacti (no specific identification)
Camellia spp.
Carnation
Cassia bicapsularis
Chenopodium amaranticolor
Chrysanthemum
Cissus antartica (Kangaroo Vine)
Cocculus laurifolius
Codonopsis spp.
Crassula spp.
Cyclamen spp.
Cypripedium spp. (injured by aerosols)
Dahlia spp.
Dianthus spp.
Dieffenbachia exotica
Echeveria elegans
Echeveria harmisii
Euphorbia spp.

MALATHION* Continued
Euphorbia pulcherrima
Feijoa sellowiana
Ferns (no specific identification)
Ficus spp.
Ficus carica
Ficus cyathistipula
Ficus diversifolia
Ficus pumila
Fuchsia spp.
Gardenia spp.
Gardenia jasminoides
Gerbera spp.
Gesneriaceae (no specific identification)
Gloxinia
Hedera spp.
Hibiscus rosa-sinensis
Hydrangea spp.
Ilex rotunda
Impatiens spp.
Kalanchoe spp.
Lilium longiflorum
Mathiola spp. (injured by aerosols)
Nephrolepsis exaltata (Florida Ruffle Fern)
Orchids (no specific identification)
Peperomia spp.
Petunia spp.
Philodendron "friedrichstahli"
Pilea spp.
Pilea cadierei
Poinsettia (injurious to bracts of "San Diego")
Primula spp.
Rieger Begonia
Reinwardtia trigyna
Rochea coccinea
Rose
Saintpaulia spp.
Schlumbergera gaertneri
Scindapsus aureus (var. "Marble Queen")
Sinningia spp. (injured by aerosols)
Syngonium podophyllum (var. "Green Gold" and "Emerald Gem") (Nephthytis)

MARLATE* (methoxychlor)
Chrysanthemum (var. "Iceberg", "Mefos" and "Winter Carnival")

METALDEHYDE*
Cattleya spp.
Ferns (no specific identification)
Gerbera spp.
Phalaenopsis spp.

META-SYSTOX-R* (oxydemeton-methyl)
Achimenes longiflora
Adiantum cuneatum (Maidenhair fern)
Aeschyanthus lobbianus
Anthurium scherzerianum
Aralia spp.
Brassaia actinophylla (Schefflera)
Carnation
Chrysanthemum (var. "Balcombe", "Perfection", "Christmas Greetings", "Friendly Rival", "Galaxy", "Golden Balcombe", "Harlequin", "Hi-Fi", "Hurricane", "Iceberg", "The Minstrels", "Moonbeam", "Pennant", "Princess Anne", "Revelry", "Silversmith", "Taffeta", "Yellow Fred Shoesmith", "Whitecap" and injurious to blossoms of "Nob Hill")

META-SYSTOX-R* (oxydemeton-methyl) Cont.
Colanthe
Echeveria elegans
Echeveria harmisii
Euphorbia pulcherrima (Poinsettia)
Euphorbia splendens
Ferns (no specific identification)
Freesia spp.
Fuchsia spp.
Gerbera jamesonii
Hedera spp.
Lilium longiflorum
Nerium spp.
Orchids (no specific identification)
Pelargonium hortorum (Geranium)
Phragmipedium spp.
Rieger Begonia
Rochea spp.
Stanhopea spp.
Zinnia spp.

MORESTAN* (oxythioquinox)
Aphelandra squarrosa (Zebra Plant)
Aralia spp.
Crassula arborescens
Fuchsia spp. (injurious to blossoms)
Hydrangea spp.
Impatiens spp. (injurious to blossoms)
Kalanchoe spp.
Nicotiana spp.
Pelargonium hortorum
Poinsettia (injurious to the bracts of "Annette Hegg")
Rose
Sweet Pea

NICOTINE SULFATE*
Spray:
Acalypha hispida
Adiantum spp.
Anthurium spp.
Antirrhinum spp.
Asparagus plumosus
Aster spp.
Astilbe spp.
Carnation
Chrysanthemum
Chrysanthemum indicum
Cissus antartica (Kangaroo Vine)
Crassula spp.
Cyclamen spp.
Dianthus spp.
Fatsia japonica
Ferns (no specific identification)
Gardenia spp.
Gladiolus spp.
Gloxinia

NICOTINE SULFATE* Continued

Spray cont.:
Hedera spp.
Kalanchoe spp.
Nerium spp.
Primula spp.
Saintpaulia spp.
Salvia spp.
Senecio spp.
Sinningia spp.
Streptocarpus spp.

Aerosols injurious to foliage of:
Cineraria spp.
Hydrangea spp.
Impatiens spp.
Mimosa spp.
Tulip

Aerosols injurious to blossoms of:
Snapdragon
Geranium

OMITE* (propargite)
Aphelandra squarrosa (Zebra Plant)
Brassaia actinophylla (Schefflera)
Carnation (injurious to blossoms)
Chrysanthemum (injurious to the blossoms of var. "Nob Hill", "White Anne", "Deep Snow Pink" and "Orange Bowl")
Collinia elegans
Dieffenbachia exotica
Nephrolepis exaltata (Florida Ruffle Fern)
Peperomia spp.
Peperomia obtusifolia
Poinsettia (injurious to bracts of "San Diego")
Scindapsus spp.
Scindapsus aureus

ORTHENE* (acephate)
Brassaia actinophylla (Schefflera)
Carnation
Chamaedorea elegans
Chrysanthemum (injurious to foliage of var. BGA "Mountain Sun" and "Always Pink"; injurious to blossoms of var. "Nob Hill" and BGA "Always Pink", "Charm", "Illini Hot Pink", "Bridesmaid" and "Mountain Sun")
Maranta spp.
Nephrolepis exaltata (Florida Ruffle Fern)
Saintpaulia spp. (injurious to blossoms)
Geranium (var. "Yours Turly", "Miles Standish", "Red Perfection", "Sincerity", "Snow Mass", "Dawn", "Easham", "White Mountain" and "Minnetonka")
Poinsettia (injurious to bracts of var. "Paul Mikkelsen" and "Mikkelwhite")

PARATHION*
Acalypha spp.
Acalypha hispida
Adiantum spp.
Aeonium decorum
Aeonium deltoidea
Aeonium haworthii
Aeonium tournefortii

PARATHION* Continued

Ageratum spp.
Aglaonema spp.
Alternanthera spp.
Ampelopsis heterophyla elegans
Anemone spp.
Anthurium spp.
Anthurium scherzerianum
Aphelandra spp.
Aquilegia spp.
Aralia spp.
Asparagus plumosus
Aster spp.
Aucuba spp.
Azalea spp.
Begonia spp.
Beloperone guttata
Bougainvillea spp.
Bouvardia spp.
Bromeliaceae (no specific identification)
Brunfelsia spp.
Calceolaria spp.
Callistephus chinensis
Carnation
Chinese evergreen
Chrysanthemum
Chrysanthemum indicum
Cissus antartica
Codiaeum spp.
Coleus spp.
Crassula spp.
Crassula arborescens
Crassula multicava
Cyclamen spp.
Dahlia spp.
Dianthus spp.
Dieffenbachia picta
Dizygotheca elegantissima
Drejerella guttata
Echeveria spp.
Erica spp.
Euphorbia spp.
Euphorbia fulgens
Euphorbia pulcherrima
Fatshedera Ivy
Ferns (no specific identification)
Ficus spp.
Ficus benjamina
Ficus carica
Ficus elastica (var. "Decora")
Ficus pumila
Forsythia spp.
Freesia spp.
Gardenia spp.
Gardenia jasminoides
Gladiolus spp.
Gloxinia
Gynura spp.
Hedera spp.
Hedera helix
Hibiscus rosa-sinensis
Hydrangea spp.
Ilex rotunda

PARATHION* Continued

Impatiens spp.
Jasminum sambac
Kalanchoe spp.
Laburnum spp.
Lathyrus spp.
Lilac
Lilium longiflorum
Lilium spp.
Lotus bertholetii
Lupinus spp.
Mathiola incana
Monstera spp.
Moschosma riparia
Nasturtium
Nephrolepis cordifolia
Nephrolepis exaltata
Orchids (injured by aerosols)
Pachyphytum spp.
Pelargonium spp. (Geranium)
Peperomia spp.
Pereskia spp.
Phalaeonopsis spp.
Philodendron spp.
Philodendron selloum
Philodendron mendlandi
Pilea cadierei
Poinsettia
Polyscias guilfoylei
Pothos
Primula spp.
Pteris spp.
Rhoicissus rhomboidea
Rieger begonia
Rochea spp.
Rochea coccinea
Rose
Saintpaulia spp.
Sanchezia spp.
Sansevieria spp.
Schlumbergera gaertneri
Scindapsus spp.
Scindapsus aureus
Sempervivum tectorum
Sinningia spp.
Spathiphyllum spp.
Stephanotis spp.
Stocks
Streptocarpus spp.
Streptosolen jamesonii
Succulents (no specific identification)
Syngonium spp.
Tibouchina spp.
Tolmiea menziesii

PENTAC*

Chrysanthemum (injurious to blossoms of var. "Nob Hill")
Gloxinia
Kalanchoe sp. cv. "Korall"
Kalanchoe sp. cv. "Rotkappchen"

PHOSVEL* (leptophos)

Brassaia actinophylla (Schefflera)
Nephrolepis exaltata (Florida Ruffle Fern)
Peperomia obtusifolia
Peperomia obtusifolia variegata

PIRIMOR (pirimicarb)

Bellis spp.
Chrysanthemum (injurious to foliage of var. BGA "Wildfire", "Always Pink", "Charm", "Illini Hot Pink", "Ice Cap" and "Gold Cap": injurious to blossoms of BGA "Always Pink", "Illini Hot Pink" and "Nob Hill")
Note: Chrysanthemum varieties not injured by Pirimor are given in Manufacturer's technical data sheet and in Florogram, Vol. VIII, No. 1, Jan.-Feb. 1975.
Delphinium
Lilium longiflorum (injurious as a soil drench)

PLICTRAN*

Avocado
Carnation
Chrysanthemum (injurious to foliage of var. "Nob Hill"; injurious to blossoms of var. "Snow Pink", "Nob Hill", "Orange Bowl", "Yellow Delaware", "Hostess" and "Yellow Bonnie Jean")
Cissus rhombifolia (Grape Ivy)
Crassula oleracea (Jade Plant)
Croton (hybrid)
Iresine herbstii
Kalanchoe diagremontiana (Mother of Thousands)
Kalanchoe sp. cv. "Korall"
Kalanchoe sp. cv. "Rotkappchen"
Orange (ornamental)
Poinsettia (injurious to bracts of "Paul Mikkelsen", "San Diego" and "White Cloud"; injurious to bracts and foliage of var. "Red Velvet" and "Annette Hegg")
Rose (damage to new growth, calyx and flower petal reported for following varieties: "American Beauty", "Bridal Pink", "Cara Mia", "Coed", "Forever Yours", "Garnet", "Golden Wave", "Jack Frost", "Junior Bridesmaid", "Mary De Vor", "Seventeen", "Tropicana", "Woburn Abbey", "Zorina")

PYRENONE* (pyrethrins)

Poinsettia (injurious to bracts of var. "Paul Mikkelsen" and "Mikkelwhite")

RESMETHRIN* (SBP-1382)

Chrysanthemum (injurious to blossoms of var. "Shoesmith", "Nob Hill", "Neptune", "Deep Snow Pink", "Orange Bowl" and "Marguerita")
Poinsettia (injurious to bracts of var. "Paul Mikkelsen" and "Mikkelwhite")
Red Calceolaria

SEVIN* (carbaryl)

Adiantum sp. (Maidenhair fern)
Parthenocissus sp. (Boston Ivy)
Brassaia actinophylla (Schefflera)
Hedera helix (English Ivy)
Nephrolepis exaltata (Florida Ruffle Fern)
Peperomia spp.
Pilea cadierei (Aluminum Plant)
Syngonium sp. (Nephthytis)
Virginia creeper

SULFOTEPP*
Carnation
Poinsettia (injurious to bracts)
Rose
Vinca spp

SYSTOX* (demeton)
Adiantum cuneatum
Alternanthera spp.
Amaryllis belladonna
Anthurium spp.
Asparagus fern
Azalea spp.
Begonia spp.
Begonia coccinea
Begonia foliosa
Begonia semperflorens
Camellia japonica
Camellia sasangua
Cattleya spp.
Chrysanthemum
Chrysanthemum indicum
Cibotium fern
Cineraria spp.
Coleus blumei verschaffeltii
Cyclamen spp.
Euphorbia spp.
Euphorbia fulgens
Euphorbia milii
Euphorbia pulcherrima
Fern (no specific identification)
Ficus carica
Fittonia verschaffeltii "argyroneura"
Fuchsia hybrida
Gardenia jasminoides
Gardenia veitchii
Geranium (injurious as a soil drench)
Gerbera jamesonii
Helxine soleirolii
Hibiscus rosa-sinensis
Hydrangea macrophylla
Ilex rotunda
Impatiens spp.
Kalanchoe spp.
Lilium longiflorum (injurious to foliage as a spray and as a soil drench)
Monstera spp.
Poinsettia
Saintpaulia spp.
Saintpaulia ionantha
Scindapsus spp.
Spironema fragrans
Violet

TEDION* (tetradifon)
Acalypha spp.
Anemone spp.
Anthurium spp.
Begonia spp.
Brassaia actinophylla (Schefflera)
Brunfelsia spp.
Calceolaria spp.
Chrysanthemum
Cineraria spp.

TEDION* (tetradifon) Continued
Cissus spp.
Cissus antartica (Kangaroo Vine)
Cyclamen spp.
Cypripedium spp. (injured by aerosols)
Dahlia spp. (injured by aerosols)
Dianthus spp.
Euphorbia spp.
Ficus diversifolia
Freesia spp.
Gardenia spp.
Gladiolus spp.
Hibiscus spp.
Hydrangea spp.
Kalanchoe spp.
Lathyrus spp.
Mathiola spp. (injured by aerosols)
Pelargonium spp.
Primula spp. (injured by aerosols)
Rochea spp.
Rose
Schlumbergera gaertneri
Senecio spp.
Sinningia spp. (injured by aerosols)
Stephanotis

THIODAN* (endosulfan)
Anthurium spp.
Chrysanthemum (var. "Bonaffon Deluxe", "Fred Shoesmith", "White Knight")
Cissus antartica
Crepe Myrtle
Crossandra spp.
Gardenia spp.
Gardenia jasminoides
Gloxinia
Poinsettia (injurious to the bracts of var. "Paul Mikkelsen" and "Mikkelwhite")
Rhoicissus rhomboidea
Rose
Saintpaulia spp.
Scindapsus spp.
Scindapsus aureus

TEMIK* (aldicarb)
Chrysanthemum (pot mums var. "White Carnival" and "Princess Anne")
Freesia spp.
Rieger begonia
Vinca major

VAPONA* (dichlorvos)
Ageratum
Aster
Chrysanthemum (var. "Dwan Star", "Shasta" "Taffeta", "Pink Champagne", "Nightingale")
Cissus antartica
Poinsettia (injurious to bracts)
Rose
Snapdragon and *Tradescantia spp.*

VYDATE* (oxamyl)
Brassaia actinophylla (Schefflera)
Dracaena godseffiana (Gold Dust Plant)
Podocarpus macrophylla

ZECTRAN* (mexacarbate)
Brassaia actinophylla (Schefflera)
Cape Chestnut
Geraldton waxflower
Ferns:
Adiantum hispidulum
Adiantum decorum
Adiantum farleyense [*sic*]
Adiantum coucatum [*sic*]
Asplenium bulbiferum
Diplazium esculentum
Dryopteris dentata
Hisplenum quercum [*sic*]
Nemia phyllifidis [*sic*]
Nephrolepis exaltata bostoniensis
Pityrogramma x-hybrida
Pteris vittata
Pteris cretica
Tectaria cicutaria
High rates of chemical may damage new growth of roses and phlox.

PESTICIDE COMBINATIONS

DITHIO plus TEDION
Cattleya orchids

DYLOX plus META-SYSTOX-R
Brassaia actinophylla (Schefflera)
Nephrolepis exaltata (Florida Ruffle Fern)
Podocarpus macrophylla

SOURCES

Florida Flower Growers - Florida Cooperative Extension Service

Vol. 8	No. 10
Vol. 11	No. 9
Vol. 12	No. 4
Vol. 12	No. 5
Vol. 12	No. 6
Vol. 12	No. 9

Florida Foliage Grower - Florida Cooperative Extension Service

Vol. 8	No. 8
Vol. 11	No. 4
Vol. 12	No. 1
Vol. 12	No. 4
Vol. 12	No. 9
Vol. 13	No. 1

Florogram - Massachusetts Cooperative Extension Service

Vol. V	No. 1
Vol. V	No. 6
Vol. VI	No. 1
Vol. VI	No. 6
Vol. VII	No. 3
Vol. VII	No. 5
Vol. VIII	No. 5

Flower & Nursery Report - University of California, May 1974.

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Nova Scotia Horticulture and Biology Service Bulletin - Circular "E 71-2".

Ornamental Plants Entomologists Newsletter [OPEN] - Western Washington Research & Extension Center

"The Sensitivity of Ornamental Plants to Insecticides and Acaracides" by John Forsyth and Joyce Maynard. Commonwealth Agricultural Bureau - Bucks, England.

POISON CONTROL CENTERS IN MASSACHUSETTS

Emergency Services Maintained 24 hrs. - All Points

Important information from label for Physician and Poison Control Center:

[1] Complete common and trade names; [2] Ingredients(s) and Percentage; [3] Manufacturer's name and address. It will also be helpful to provide information as to whether the poisoning occured via oral or dermal routes or by inhalation. The length of exposure, approximate amount ingested, and general reaction or behavior of the victim are also helpful.

BOSTON	Poison Information Center Dr. F.H. Lovejoy, Jr., Exec. Sec. Children's Medical Center 300 Longwood Avenue, 02115	Area Code 617 232-2120
FALL RIVER	Poison Control Center Union Hospital 300 Hanover Street, 02720	Area Code 617 674-5789
NEW BEDFORD	Poison Control Center St. Luke's Hospital 101 Page Street, 02740	Area Code 617 997-1515 Ext. 311, 312
SPRINGFIELD	Poison Control Center Mercy Hospital 233 Carew Street, 01104	Area Code 413 788-7321 Ext. 229, 301
	Poison Control Center Springfield Hospital 759 Chestnut Street, 01107	Area Code 413 787-3233
	Poison Control Center Wesson Memorial Hospital 140 High Street, 01105	Area Code 413 787-2562
WORCESTER	Poison Control Center Worcester City Hospital 71 Jacques Street, 01603	Area Code 617 799-7094

In the event of a pesticide spill or accident *during transportation*, 24 hr. service may be secured by calling 1-800-424-9300. For chemical analysis of unknown pesticides and general information, the Massachusetts Department of Public Health, Food and Drug Division, may be called at 617-727-0260 or after hours at 617-837-0086.

All pesticides listed in this publication are registered and cleared for suggested uses according to Federal registrations and State laws and regulations in effect on the date of this publication. When trade names are used for identification, no product endorsement is implied, nor is discrimination intended against similar materials.

NOTICE: THE USER OF THIS INFORMATION ASSUMES ALL RISKS FOR PERSONAL INJURY OR PROPERTY DAMAGE.

WARNING: PESTICIDES ARE POISONOUS. READ AND FOLLOW DIRECTIONS AND SAFETY PRECAUTIONS ON LABELS. HANDLE CAREFULLY AND STORE IN ORIGINAL LABELED CONTAINERS OUT OF REACH OF CHILDREN, PETS, AND LIVESTOCK. DISPOSE OF EMPTY CONTAINERS RIGHT AWAY, IN A SAFE MANNER AND PLACE. DO NOT CONTAMINATE FORAGE, STREAMS, AND PONDS.